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Occidental Chemical Corporation

NIAGARA PLANT
ENGINEERING REPORT
SPDES Permit NY0003336

December 15, 1984

New York State Department of Environmental Conservation
Division of Water NY-000-3336
Bureau of Wastewater Facilities Design
Occidental Chemical Corporation
Niagara Falls (C), Niagara Co.
Approved by: Walter E. Lorcindy P.E., 8/28/85
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TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
2.0	BACKGROUND	2
3.0	CONTINUOUS FLOW MONITORING SYSTEM	4
	3.1 OUTFALL 001	5
	3.1.1 Location	5
	3.1.2 Flow Diversion for Monitoring	5
	3.1.3 Housing for Metering	6
	3.1.4 Flow Metering Range	6
	3.1.5 Maintenance By-Pass Provision	7
	3.1.6 Easements Required	7
	3.2 OUTFALL 003	8
	3.2.1 Location	8
	3.2.2 Flow Diversion for Monitoring	8
	3.2.3 Housing for Metering	9
	3.2.4 Flow Metering Range	9
	3.2.5 Maintenance By-Pass Provision	10
	3.2.6 Easements Required	10
	3.3 OUTFALL 005	11
	3.3.1 Location	11
	3.3.2 Flow Diversion for Monitoring	11
	3.3.3 Housing for Metering	12
	3.3.4 Flow Metering Range	12
	3.3.5 Maintenance By-Pass Provision	13
4.0	TOTAL AND INDIVIDUAL ORGANIC COMPOUNDS	14
	4.1 TOTAL COMPOUNDS	14
	4.2 INDIVIDUAL COMPOUNDS	15
	4.2.1 Monochlorotoluene (MCT)	15
	4.2.2 Discussion of the Source and Control of Dichlorobenzene (DCB), Trichlorobenzene (TCB), Tetrachlorobenzene (TTCB)	18

TABLE OF CONTENTS (cont'd)

		Page
4.2.3	Dichlorotoluene (DCT)	20
4.2.4	Monochlorobenzotrifluoride (MCBTF), Dichlorobenzotrifluoride (DCBTF)	20
4.2.5	Hexachlorocyclopentadiene (C-56)	21
4.2.6	Monochlorobenzene (MCB)	21
4.2.7	Toluene	21
4.2.8	Hexachlorocyclohexane	22
4.2.9	Trichloroethylene (TCE) and Tetrachloroethylene (PCE)	22
5.0	pH OUTFALL 001	25
6.0	ENGINEERING ASPECTS AND WORK PLAN OUTFALL 001 AND OUTFALL 005	26
6.1	RELINING OF SEWERS	26
6.2	REMEDIAL WORK FOR OUTFALL 005	27
6.2.1	Existing Conditions	27
6.2.2	Relining Work	27
6.2.3	Manholes	28
6.2.4	Other Active Lines	29
6.3	REMEDIAL WORK FOR OUTFALL 001	29
6.3.1	Existing Conditions	29
6.3.2	Relining Pipe	29
6.3.3	Repairing of Manholes	29
6.3.4	~~Sewer Abandonment~~	30
6.4	CLOSURE OF OUTFALL 002	30

APPENDIX A INFORMATION ON INSITUFORM LINING
APPENDIX B ISCO REFRIGERATED SAMPLER
APPENDIX C MAGNETIC FLOWMETER

LIST OF FIGURES

		Page
Figure 1	Outfall Sewer Network	1a
Figure 2	Outfall 001 Monitoring Station	5a
Figure 2a	Outfall 001 Monitoring Station Schematic	5b
Figure 3	Outfall 003 Monitoring Station	8a
Figure 3a	Outfall 003 Monitoring Station Schematic	8b
Figure 4	Outfall 005 Monitoring Station	11a
Figure 4a	Outfall 005 Monitoring Station Schematic	11b
Figure 5	Outfall 005 West	16a
Figure 6	Outfall 005 East	16b
Figure 7	Outfall 005 1980 Chlorotoluene Data	17a
Figure 8	Outfall 005 1981 Chlorotoluene Data	17b
Figure 9	Outfall 005 1980 Dichlorobenzene Data	19a
Figure 10	Outfall 005 1981 Dichlorobenzene Data	19b
Figure 11	Outfall 005 1980 Trichlorobenzene Data	19c
Figure 12	Outfall 005 1981 Trichlorobenzene Data	19d
Figure 13	Outfall 005 1980 Tetrachlorobenzene Data	19e
Figure 14	Outfall 005 1981 Tetrachlorobenzene Data	19f
Figure 15	Outfall 001	22a
Figure 16	Outfall 001 1980 Trichloroethylene Data	23a
Figure 17	Outfall 001 1981 Trichloroethylene Data	23b
Figure 18	Outfall 001 1980 Tetrachloroethylene Data	23c
Figure 19	Outfall 001 1981 Tetrachloroethylene Data	23d
Figure 20	Outfall 005 Existing Conditions and Work Plan	27a
Figure 21	Outfall 001 Existing Conditions and Work Plan	29a
Figure 22	Outfall 002 Closure Details	30a

LIST OF TABLES

		Page
TABLE 1	Summary of Total Loading Reduction with 85% Reduction in Outfall 005 and 001	15a 15b
TABLE 2	Existing levels for Monochlorotoluene	15c
TABLE 3	Monochlorotoluene Loading in Outfall 005	15d
TABLE 4	Limits for Trichloroethylene and Tetrachloroethylene	22a

1.0 INTRODUCTION

As requested by Mr. P. Foersch, the report by Nolan Curry "Engineering Report Requirements, Wastewater Treatment for Chemical Systems" was reviewed but was felt to be inappropriate in preparing detailed aspects of this report. The general principles of defining the wastewater problem and justifying a solution were, however, followed.

The report, as requested, reiterates how the limits were established and what assumptions were made on behalf of Occidental and NYSDEC.

This report addresses the outfall sewer system shown on Figure 1, and discusses the following items:

- Installation of Continuous Flow Meters
- Total and Individual Organic Reductions
- pH Outfall 001
- Closure of Outfall 002

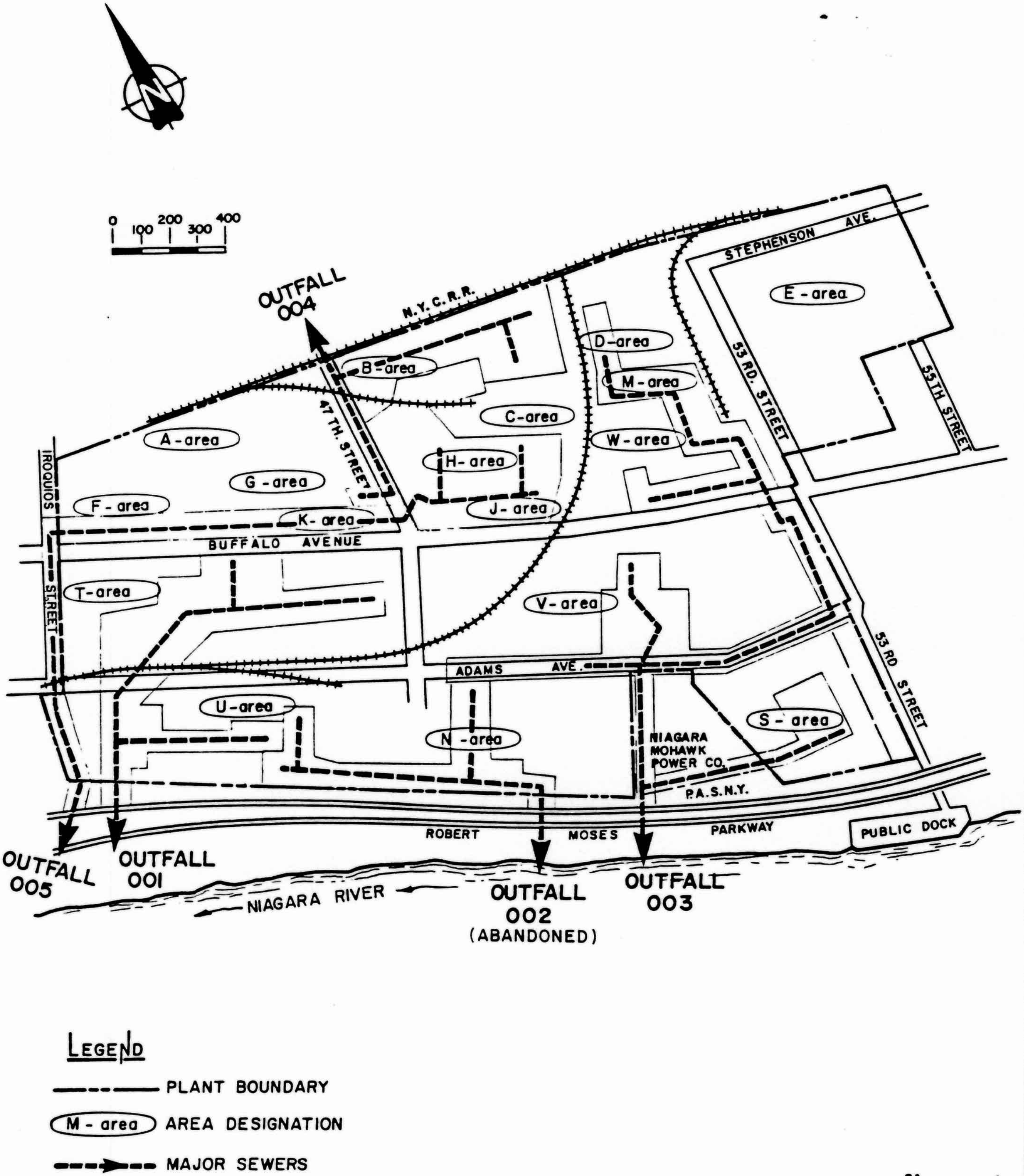

figure 1

OUTFALL SEWER NETWORK

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2.0 BACKGROUND

Occidental Chemical Corporation (OCC) received a new SPDES Permit which was effective in November 1984. The Consent Order accompanying the permit contains Schedule A, attached, which requires remedial action and engineering reports to be submitted. The following general measures are planned as a result of the permit. Additional details are provided later in this report.

- Continuous Flow Requirement

  The permit requires continuous flow monitoring at the following locations:

  - Outfall 001
  - Outfall 003
  - Outfall 005

  Continuous flow monitors will be installed so that a flow proportional sample can be collected.

- Total and Individual Organic Discharge Reduction

  The permit limits for total organics change from 284 lb/day to 74 lb/day. Individual limits are also established. Several reports have been submitted to DEC describing loadings in each outfall. Based on the reports submitted,

SCHEDULE A

Respondend shall, on or before the following dates, initiate the following compliance actions to meet final SPDES Permit No. NY0003336 limitations at all Outfalls.

Action Code	Outfall Number(s)	Compliance Action	Due Date
01	All Outfalls	Submit Approvable Engineering Report	December 15, 1984
02	All Outfalls	Submit Approvable Final Plans	May 15, 1985
04	All Outfalls	Commence Construction	July 15, 1985
05	All Outfalls	Report on Construction Progress (First Report)	October 1, 1985
06	All Outfalls	Report of Construction Progress	
		(Second Report)	January 15, 1986
		(Third Report)	April 15, 1986
		(Fourth Report)	July 15, 1986
08	All Outfalls	Completion of Construction	October 1, 1986
09	All Outfalls	Attain Operational Level	November 1, 1986
56	All Outfalls	Submit BMP Plan	October 1, 1986

sewer replacement/relining and abandonment are required in Outfalls 001 and 005 to reduce loadings. The measures to be undertaken address infiltration to the extent required to meet SPDES discharge limits as stipulated in the Consent Order.

pH - Outfall 001

OCC will be conducting a pH survey program in Outfall 001 to determine if sources of high pH still exist and are infiltration related. This initial report only describes a method devised to determine if a problem still exists and if so, to locate the source. A followup report will be submitted as to the findings.

3.0 CONTINUOUS FLOW MONITORING SYSTEM

- General

Continuous flow metering equipment will be installed in Outfalls 001, 003 and 005 which will provide an instantaneous flow reading and recording by way of a daily totalizer reading. ISCO Model 1580R refrigerated samplers (see Appendix B) will also be installed so that a flow proportional sample may be collected. See attached technical data from ISCO. Additional refrigerated ISCO samplers will be installed at the 004 and S-Area outfall to collect samples.

The magnetic flow meter working on the principle of electro-magnetic induction in electrically conductive liquids will be installed. The produced low voltage is directly proportional to velocity and is translated to volumetric flow rate. Technical information on the magnetic flow meter is contained in Appendix C.

Each meter station is detailed in the following sections.

3.1 OUTFALL 001

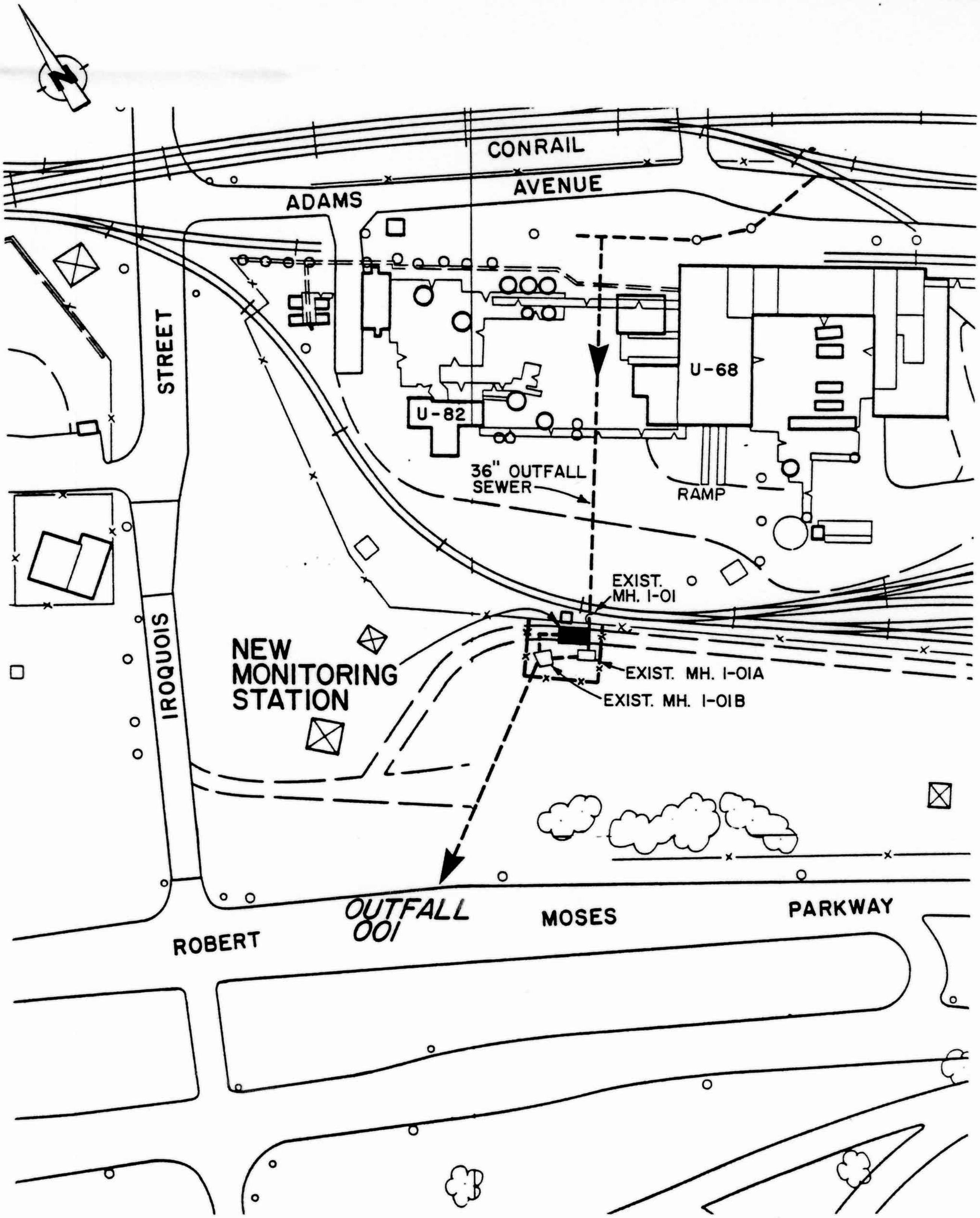
3.1.1 Location

The monitoring station will be located adjacent to the existing 36-inch outfall sewer between manhole MH1-01 and MH1-01A near the south property line as shown on Figure 2. The location is subject to PASNY approval.

3.1.2 Flow Diversion for Monitoring

The flow from the existing north-south 36-inch outfall sewer line will be intercepted in a concrete pit constructed around the 36-inch line. The 36-inch line will be removed from within the intercepting pit and a sluice gate will be installed on the line at the south wall of the intercepting pit.

The sluice gate will normally be closed and the flow will be diverted from the pit chamber through a new pipe section in which a magnetic flow tube will be installed. Knife gate valves will be installed in the new pipe section on each side of the magnetic flow tube to facilitate maintenance.



NOTE: THIS PLAN COPIED FROM 1982 AERIAL MAPPING

figure 2

OUTFALL 001
MONITORING STATION
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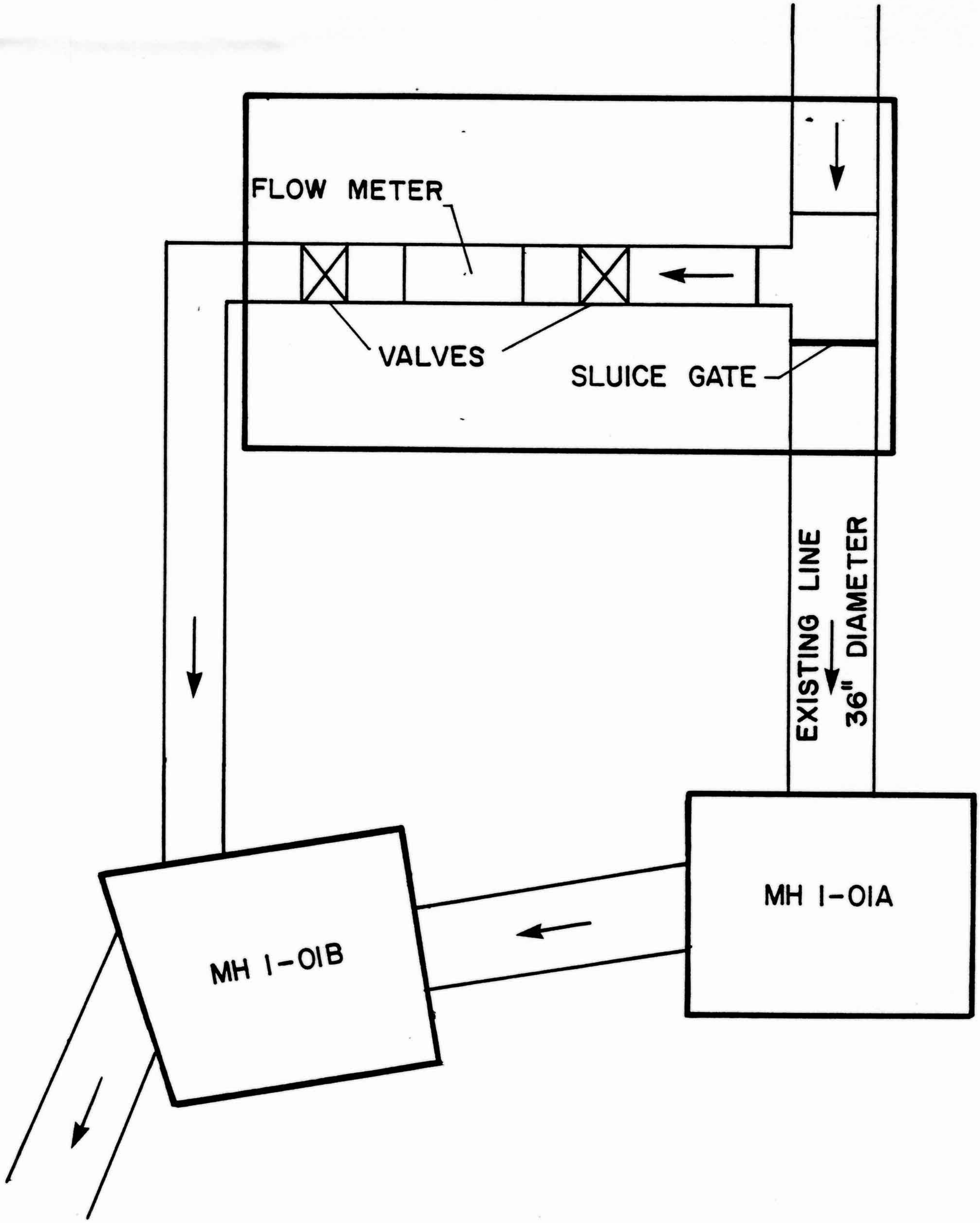

figure 2a

OUTFALL 001
MONITORING STATION SCHEMATIC
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After passing through the meter, the flow will discharge through the new pipe section back into the 001 outfall sewer at Manhole 1-01B.

3.1.3 Housing for Metering

The diversion piping section which contains the magnetic flow tube and valves will be installed in a separate concrete chamber west of the concrete intercepting pit. The pit will be covered with removable concrete sections. A manway access will be provided in one of the above sections.

Instrumentation including the flow transmitter, flow indicator, flow totalizer, flow proportional sampler and a temperature indicator will be housed in a separate above ground structure adjacent to the concrete pit.

The area around the monitoring station will be enclosed by fencing.

3.1.4 Flow Metering Range

The flow metering provided will range from 0.26 MGD to 2.6 MGD. The piping will be arranged so that a larger or smaller meter can be installed in the future if flows change.

3.1.5 Maintenance By-Pass Provision

A by-pass to the flow meter system will be provided by the installation of the sluice gate on the 36-inch line at the south wall of the concrete pit. The sluice gate will normally be closed to direct the flow of water through the flowmeter pipe system.

If the flow meter system must be by-passed, the sluice gate will be opened and the valves closed on the flow meter system to direct the flow back through the original outfall sewer.

3.1.6 Easements Required

The monitoring system will be constructed on Power Authority of the State of New York property and will require an easement from this Authority. It is anticipated that easement approvals will not be a problem.

3.2 OUTFALL 003

3.2.1 Location

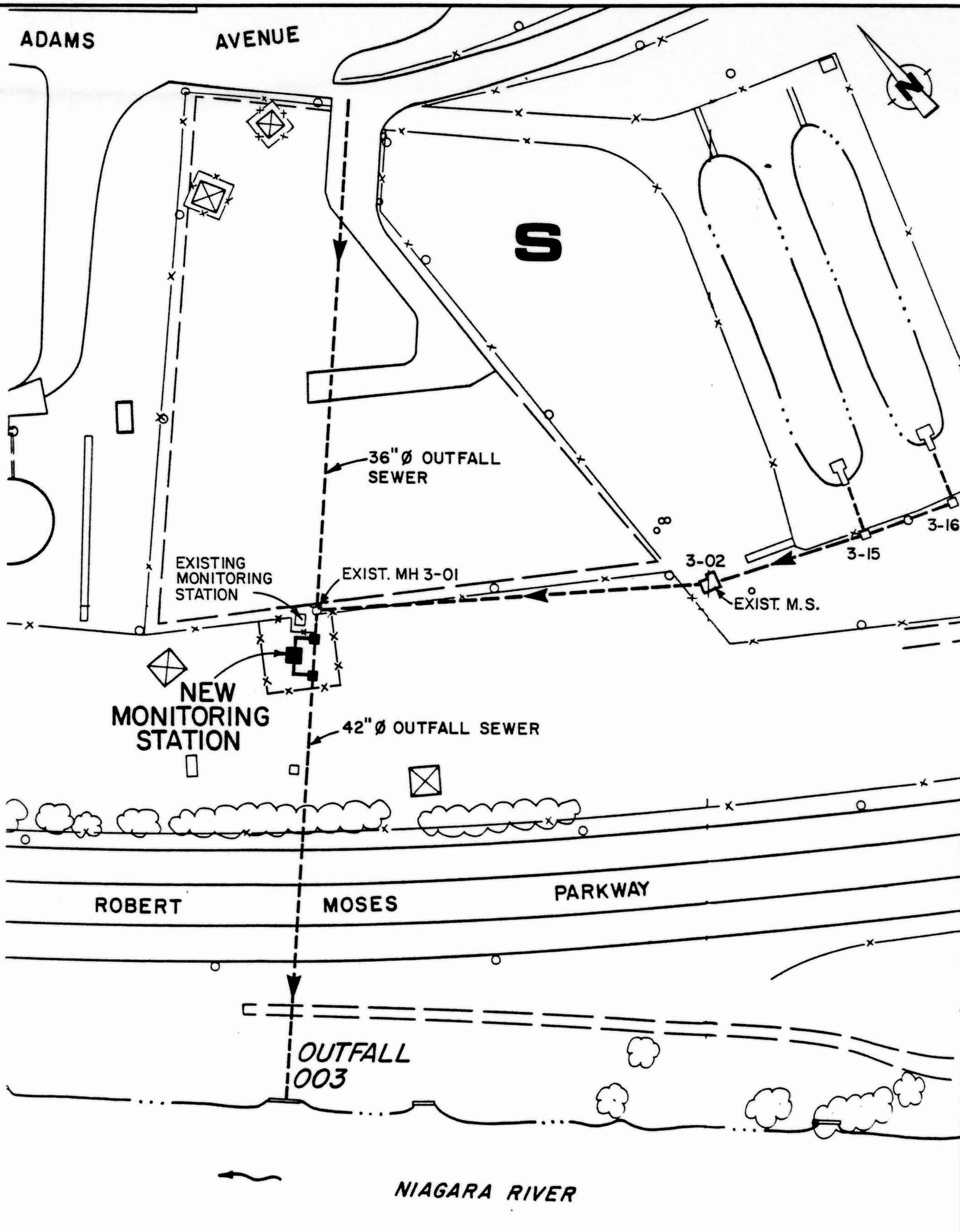
The monitoring station will be located adjacent to the 36-inch outfall sewer south of Manhole MH3-01 near the south property line as shown on Figure 3. This location was chosen because it is outside the proposed remedial work area of the S-Area Settlement Agreement.

3.2.2 Flow Diversion for Monitoring

The flow from the existing north-south 36-inch outfall sewer line will be intercepted in a concrete manhole constructed around the 36-inch line. The 36-inch line will be removed from within the intercepting manhole and a sluice gate will be installed on the line at the south face of the manhole.

The sluice gate will normally be closed and the flow will be diverted from the manhole through a new pipe section running parallel to the 36-inch sewer.

A magnetic flow tube will be installed in the pipe section and knife gate valves will be installed each side of the magnetic flow tube to facilitate maintenance.



NOTE: THIS PLAN COPIED FROM 1982 AERIAL MAPPING

figure 3

OUTFALL 003
MONITORING STATION
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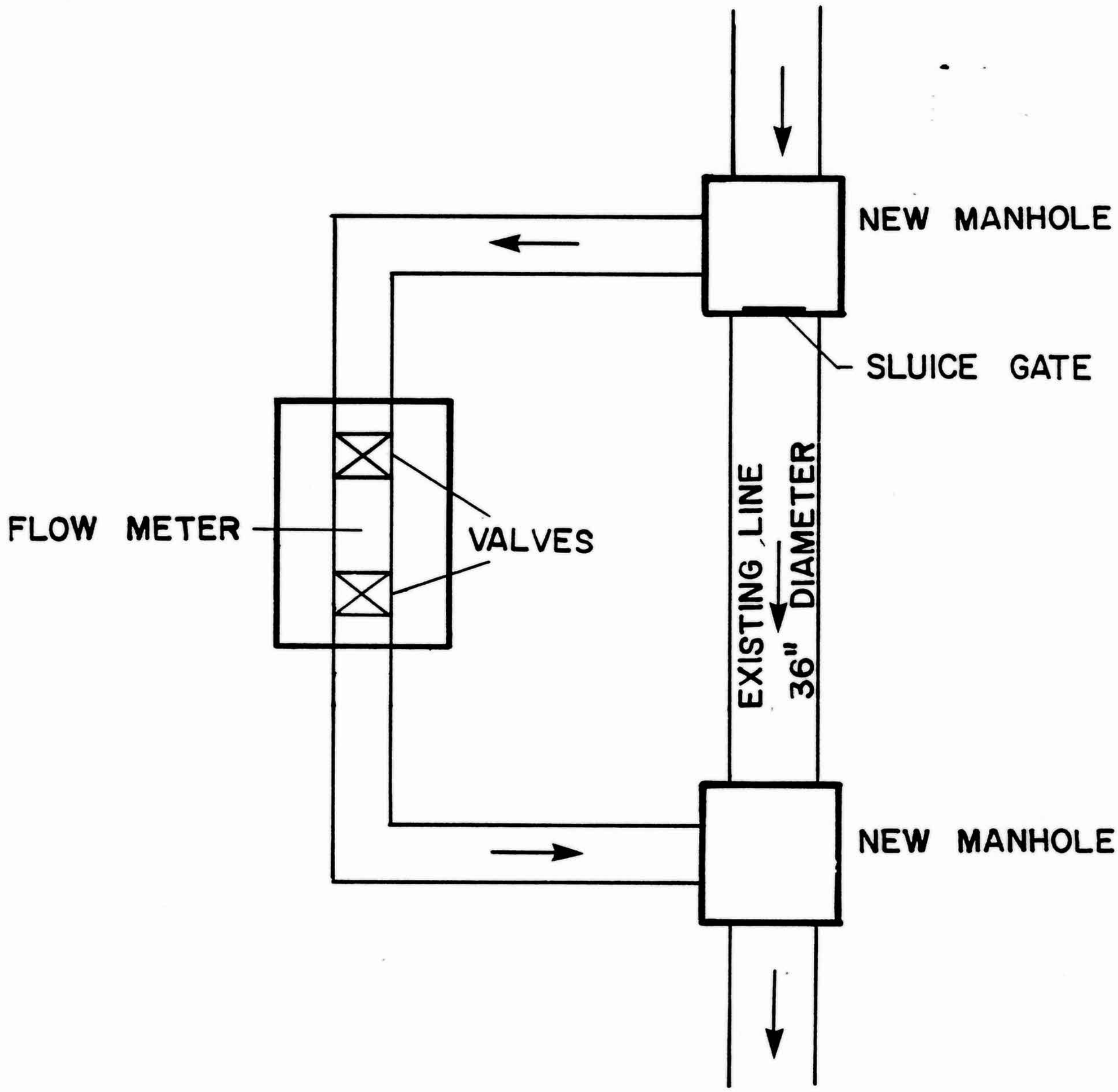

figure 3a

OUTFALL 003
MONITORING STATION SCHEMATIC
Occidental Chemical Corporation

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The new pipe section will discharge back into the 003 River Outfall through a second concrete manhole constructed on the 36-inch sewer south of the intercepting manhole.

3.2.3 Housing for Metering

The piping section which contains the magnetic flow tube and valves will be installed in a concrete pit. The pit will be covered with removable concrete sections. A manway access will be provided in one of the above sections.

Instrumentation including the flow transmitter, flow indicator, flow totalizer, flow proportional sampler and a temperature indicator will be housed in a separate above ground structure adjacent to the concrete pit.

The area around the monitoring station will be enclosed by fencing.

3.2.4 Flow Metering Range

The flow metering provided will range from 1.5 MGD to 15 MGD.

3.2.5 Maintenance By-Pass Provision

A by-pass to the flow meter system will be provided by the installation of the sluice gate on the 36-inch sewer line at the south face of the intercepting manhole.

The sluice gate will normally be closed to direct the flow of water through the flow meter pipe system.

If the flow meter system must be by-passed, the sluice gate will be opened and the valves closed on the flow meter system. The flow will then be directed back through the original outfall sewer.

3.2.6 Easements Required

The monitoring station will be constructed on Power Authority of the State of New York property and will require an easement from this authority. It is anticipated that easement approvals will not be a problem.

3.3 OUTFALL 005

3.3.1 Location

The monitoring station will be located at Pump Station K-28 near the west property line as shown on Figure 4.

3.3.2 Flow Diversion for Monitoring

The flow from the existing Pump Station in Building K-28 will be intercepted at a point above grade south of the building face.

A tee section will be installed in the existing discharge line at this point and a new above grade pipe section will be installed from the branch of the tee. It will contain a magnetic flow tube with knife gate valves inserted each side of the flow tube to facilitate maintenance.

The new pipe section will be connected into the existing 30-inch underground discharge line at an existing tee section branch which is presently capped.

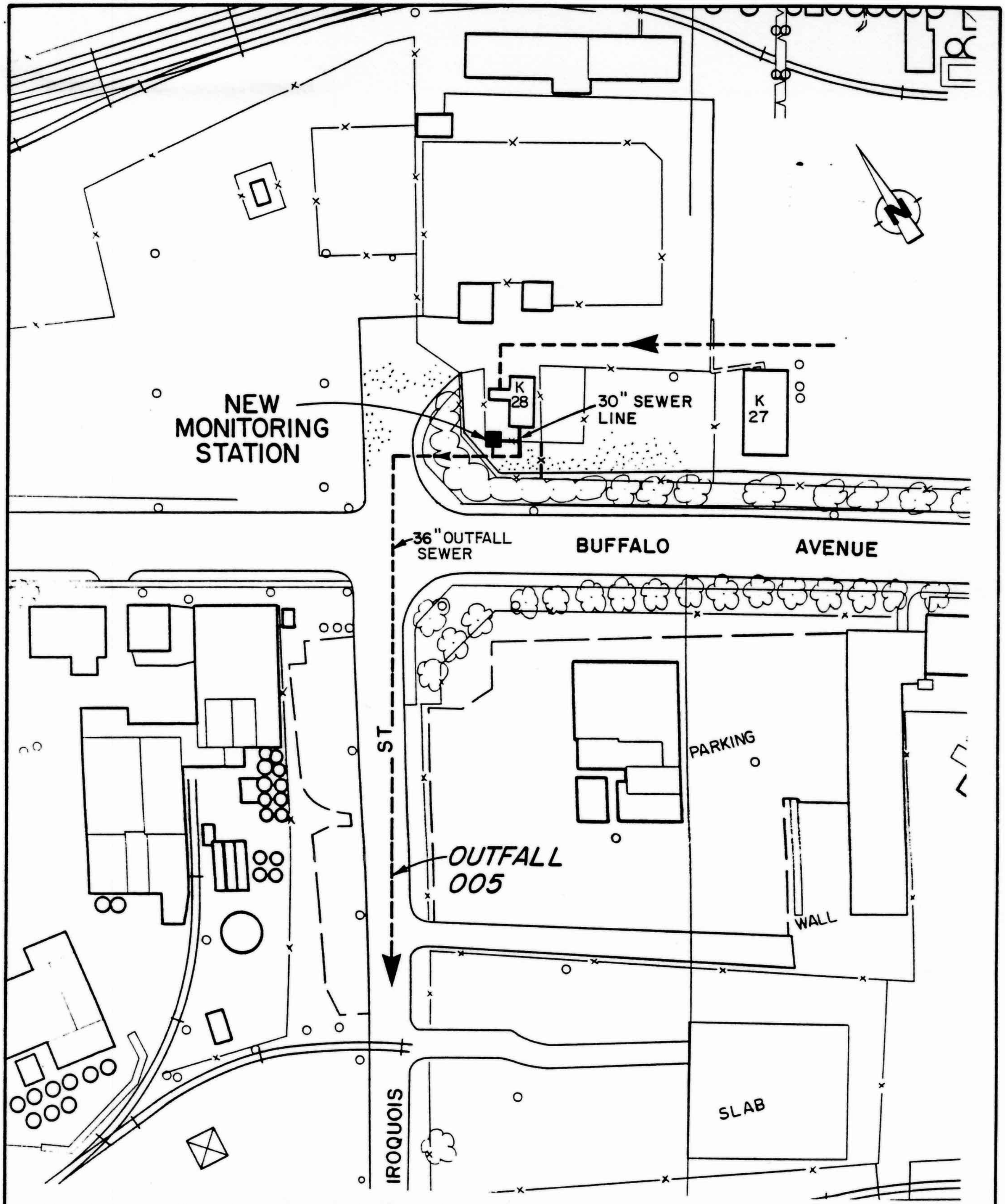

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figure 4

OUTFALL 005
MONITORING STATION
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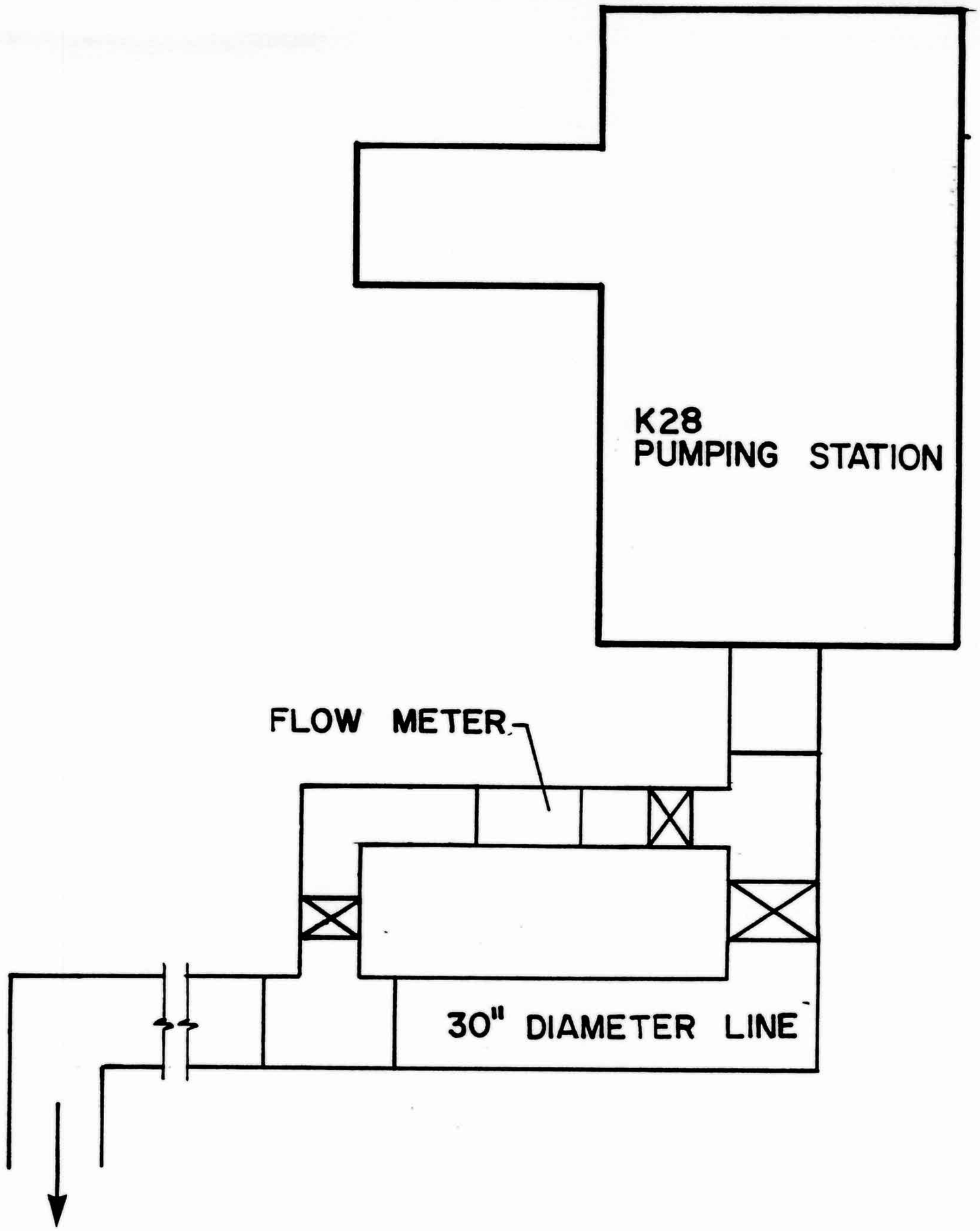

figure 4a

OUTFALL 005
MONITORING STATION SCHEMATIC
Occidental Chemical Corporation

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TABLE 2

EXISTING LEVELS FOR MONOCHLOROTOLUENE
SUMMATION OF PLANT OUTFALLS
DESCRIPTIVE STATISTICS FOR MCT

Number of observations 22
Mean 18.81

	MCT INPUT DATA	ORDERED DATA	CUMULATIVE PERCENTAGE	CUMULATIVE NORMAL	DIFFERENCE
1	12.550	0.0900	4.348	15.551	11.203
2	13.580	2.4700	8.696	18.827	10.132
3	94.070*	6.0700	13.043	24.527	11.481
4	16.910	7.2000	17.391	26.490	9.099
5	19.260	9.1300	21.739	30.019	8.289
6	9.1300	9.4900	26.087	30.700	4.613
7	20.650	10.190	30.435	32.043	1.608
8	9.4900	12.550	34.783	36.739	1.956
9	27.890	13.080	39.130	37.824	- 1.306
10	13.080	13.580	43.478	38.857	- 4.621
11	15.910	15.910	47.826	43.765	- 4.062
12	0.0900	16.810	52.174	45.690	- 6.483
13	20.980	18.530	56.522	49.396	- 7.126
14	7.2000	19.260	60.870	50.971	- 9.898
15	6.0700	19.730	65.217	51.985	-13.232
16	19.730	20.650	69.565	53.966	-15.599
17	18.530	20.980	73.913	54.674	-19.239
18	25.770	23.820	78.261	60.685	-17.575
19	26.550	25.770	82.609	64.679	-17.930
20	10.190	26.550	86.957	66.234	-20.722
21	2.4700	27.890	91.304	68.842	-22.462
22	23.820	94.070	95.652	99.998	4.346

0.2661 KOLMOGOROV-SMIRNOV STATISTIC

NOTE: Reference from DEC Statistical Analysis

* maximum value

TABLE 3

MONOCHLOROTOLUENE LOADING IN OUTFALL 005

DATE (YYDDD)	LOADING (LB/DAY)
81217	10.23
81252	6.77
81280	92.66
81308	11.63
81336	9.56
82006	10.08
82034	5.84
82062	17.55
82097	22.77
82125	2.07
82153	10.96
82188	0.00
82216	16.76
82244	6.62
82264	6.07
82307	17.15
82335	16.57
83005	21.17
83033	23.66
83061	7.77
83096	0.83
83124	18.66

MEAN = 15.24 lb/day

85% Reduction = 12.92 lb/day

Thus, the limit is established as follows:

Arithmetic mean = 18.8 lb/day

High value = 94.1 lb/day

Ratio $= \frac{\text{(High Value)}}{\text{(Mean)}} = \frac{94.1}{18.8} = 5.0$

Potential 005 reduction = 15.24 lb/day

Calculated reduction assuming 85% = 12.92 lb/day

The limit therefore becomes:

(18.8 - 12.92) (5) = 29.4 or approximately 30 lb/day

Discussion of the Sources and Control for MCT

Figure (5 & 6) outline the 005 Outfall sewer network as of the dates shown on the figures. The line services an inorganic process in the B & H Areas, an MCT production facility in F-13, F-42 and passes through a former disposal site and former chlorobenzene handling area located in the immediate area of the F-28 buildings. Several sampling programs were conducted in the past by OCC and its consultant to define sources of the loadings. The conclusions reached are as follows:

- The contribution from the inorganic processes in B & H Areas is essentially zero.

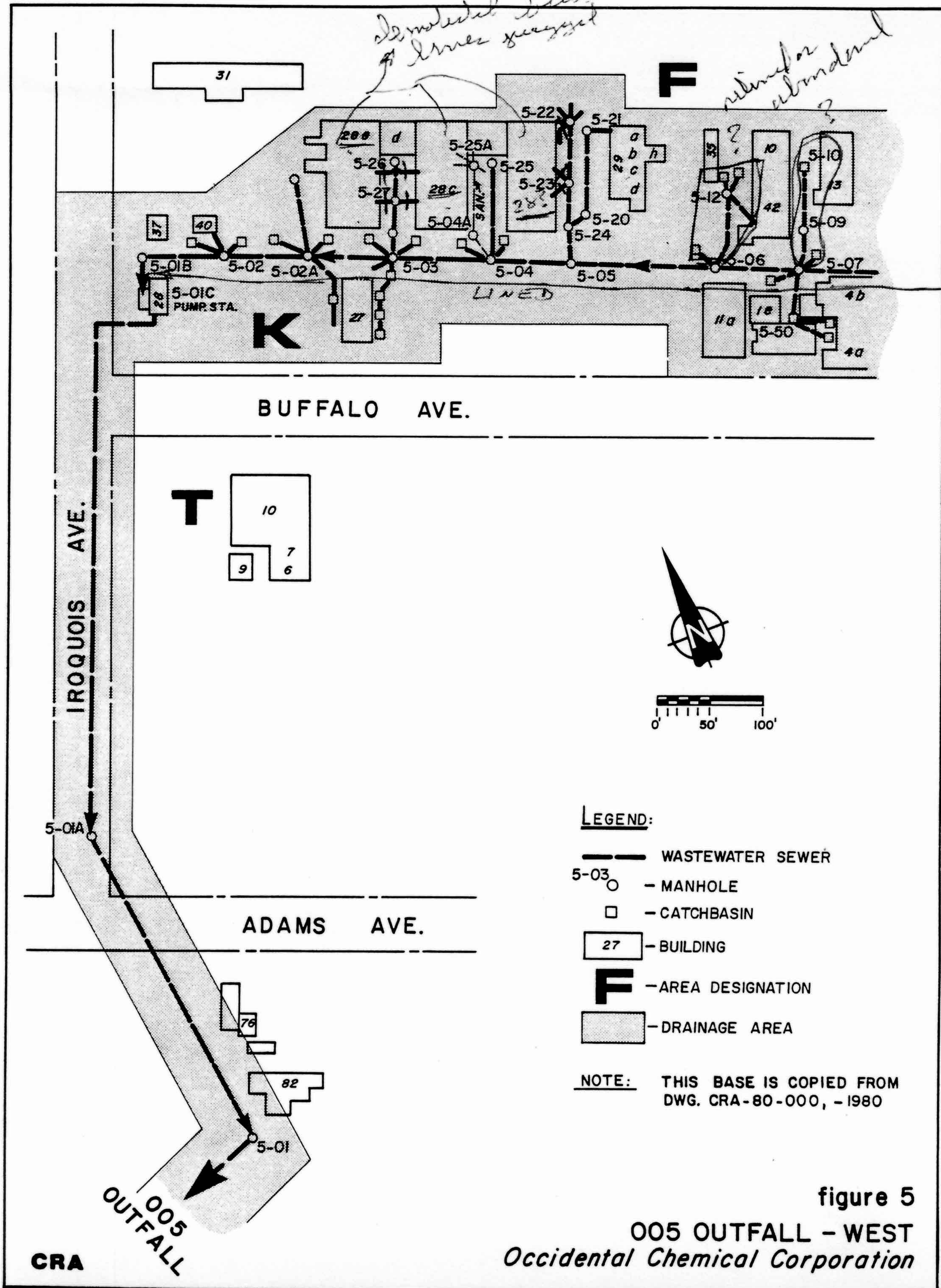

figure 5

005 OUTFALL - WEST

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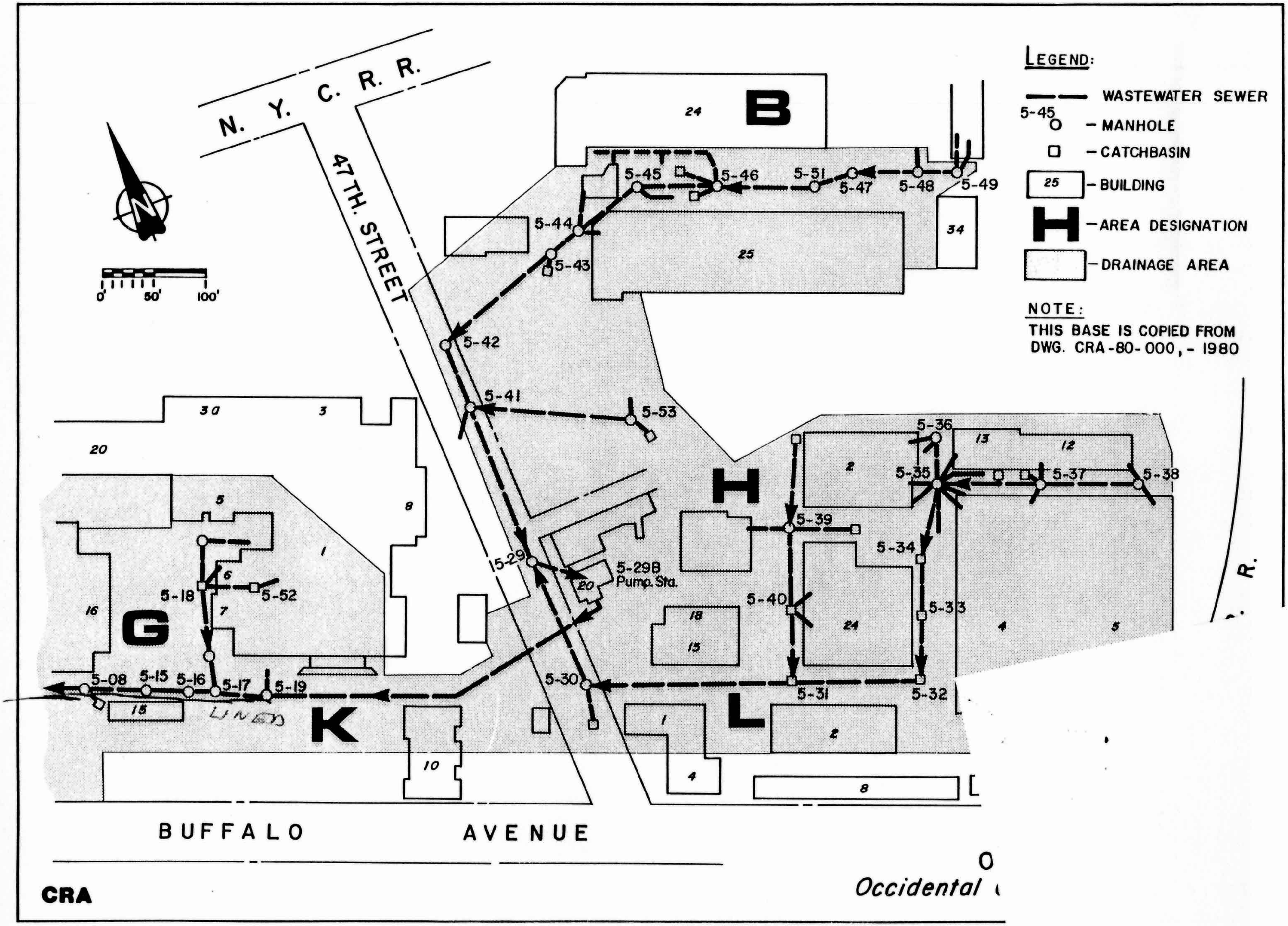
LEGEND:
WASTEWATER SEWER
5-45
MANHOLE
CATCHBASIN
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BUILDING
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AREA DESIGNATION
DRAINAGE AREA
NOTE:
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BUFFALO AVENUE
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- The current MCT facility does not contribute significantly to the 005 Outfall discharge.

- The major loading is associated with infiltration of contaminated groundwater into 005 Outfall.

These conclusions are supported by:
Figures 7 and 8, which contain sampling data from 1980 and 1981, show the following:

- At MH19 the loadings are essentially not detected (ND), thus confirming B/H Area contribution is not significant.

- The lines from the current MCT facility originating at MH5-10 and MH5-12, contributes up to 5 lb/day which is considered a small contribution on the total. All other stub flow is negligible.

- The remainder of the loadings are associated with infiltration as evidenced by the data west of MH6.

- The overburden groundwater flow is from a northeast to a southwest direction. Most of the existing outfall lines and manholes in the area are 30 to 60 years old and are in various degrees of structural deterioration. The outfall sewer is located below the groundwater table and the above conditions make the sewer system susceptible to infiltration.

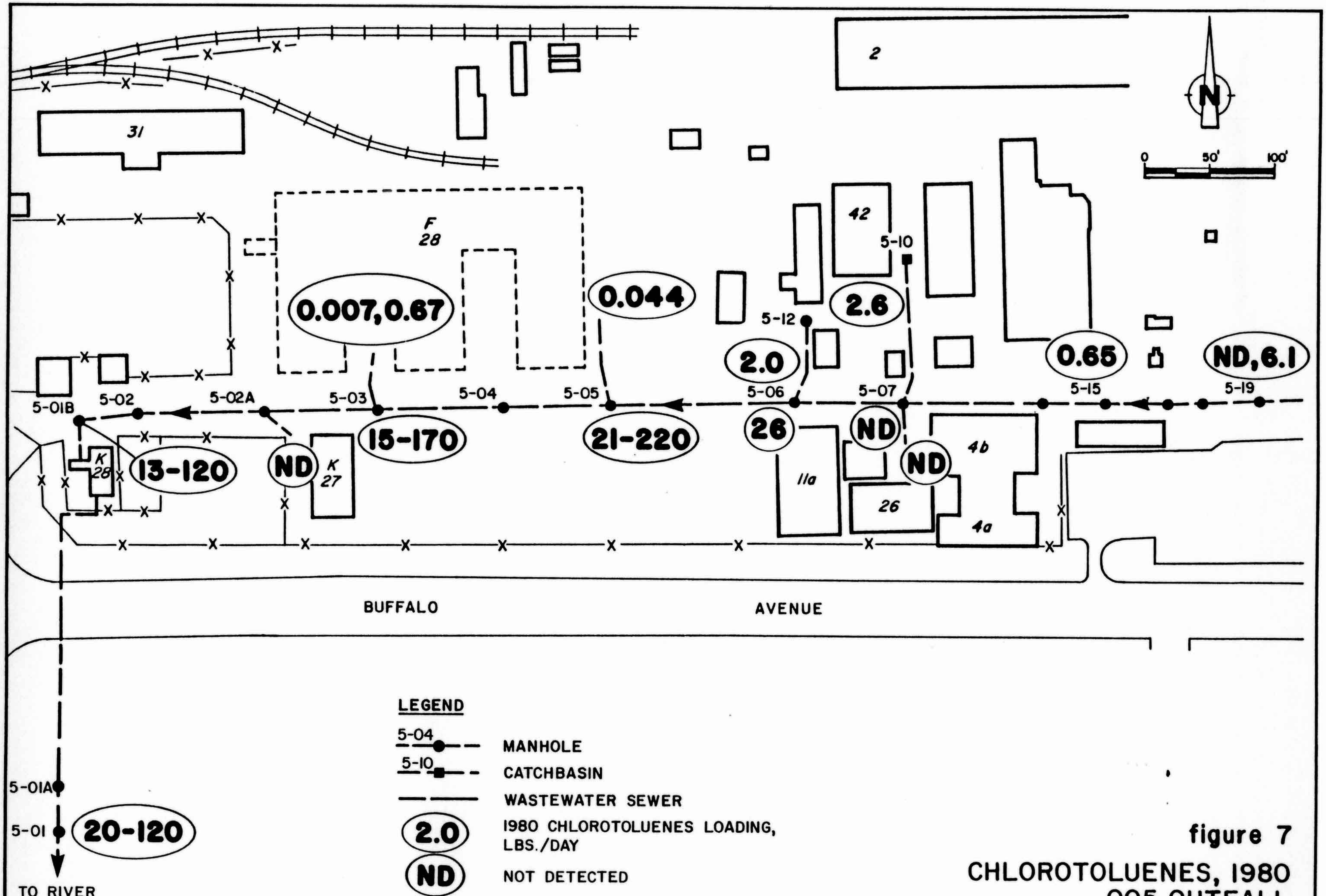

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figure 7

CHLOROTOLUENES, 1980
005 OUTFALL
Occidental Chemical Corporation

1530 - 12/12/84

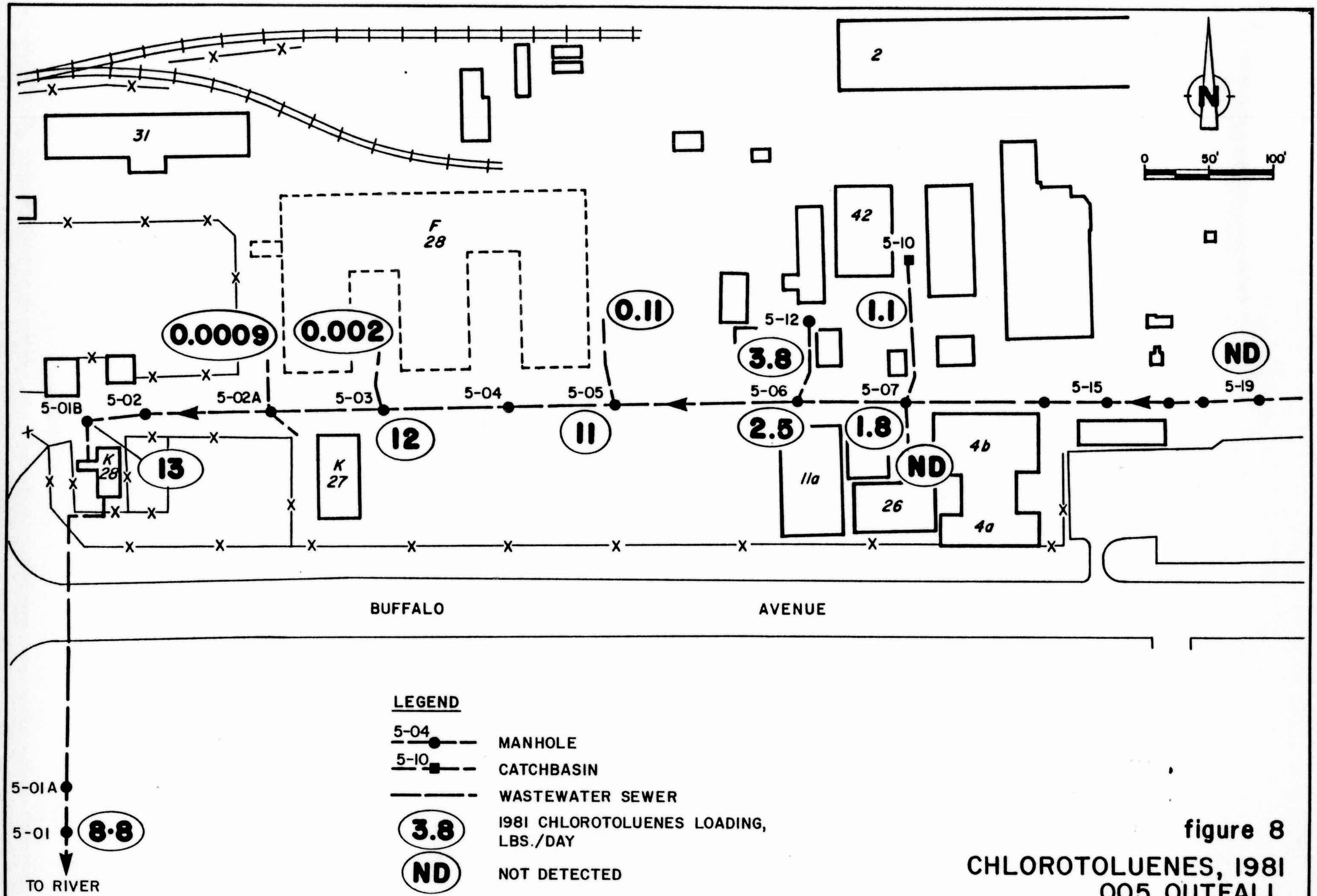

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figure 8

CHLOROTOLUENES, 1981
005 OUTFALL
Occidental Chemical Corporation

1530 -12/12/84

Remedial Solutions

The MCT facility will be relocated to the N-Area and the branch lines from manholes MH5-12 to MH5-06 and MH5-10 to MH5-07 may be permanently abandoned or relined depending on the start-up timing of the MCT facility. The F-28 buildings have been demolished and branch lines have been plugged. The infiltration of groundwater into the sewer line will be minimized by installation of a liner from manhole MH5-19 to MH5-01B adjacent to the K-28 lift station. The number of connections and live manholes will be minimized and active manholes will be made watertight. Further details outlining the engineering aspects are contained in a later section. These measures should result in an overall reduction of 85%.

4.2.2 Discussion of the Source and Control of Dichlorobenzene (DCB), Trichlorobenzene (TCB), Tetrachlorobenzene (TTCB)

The limits for these compounds were established using lognormal statistics, which were previously submitted to DEC. A reduction of 85% is required in Outfall 005 to meet these limits. The following summarized data is for the 22-month period from August 1981 to May 1983:

Compound	(1) Arithmetic Mean	(2) Potential Reduction	(3) Projected Reduction Mean	(4) Column (1)-(3)	(5) Log-normal Limit
Dichlorobenzene (DCB)	1.83	1.5	1.27	1.47	8
Trichlorobenzene (TCB)	9.37	9.31	7.9	1.0	15
Tetrachlorobenzene (TTCB)	6.9	6.9	5.9	3.02	11

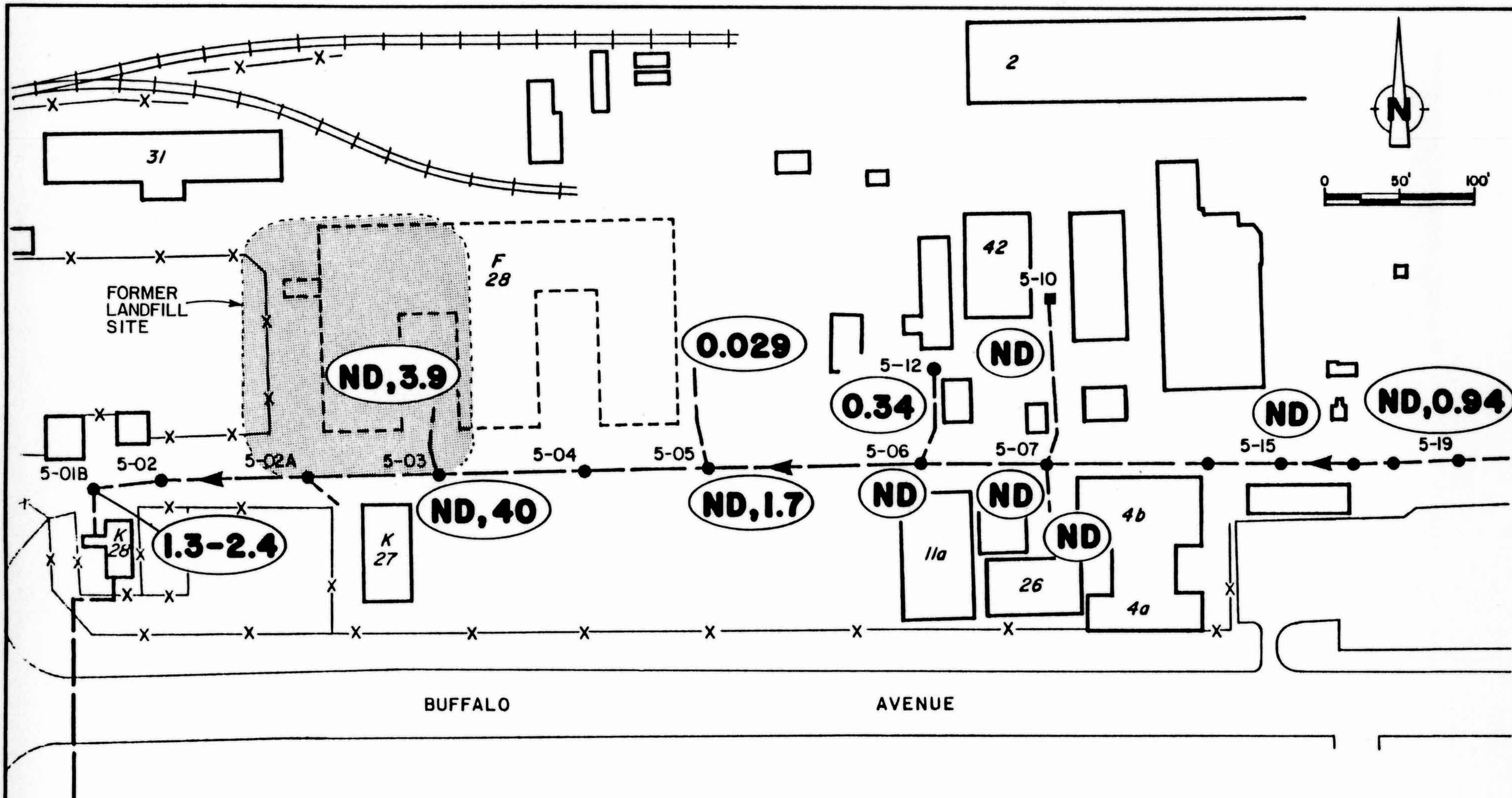
The same discussion applies for chlorinated benzene as for monochlorotoluenes under Section 4.2.1. The F-28 and K-Area formerly handled chlorinated benzene materials. Approximately 1400 tons of chlorinated benzene were disposed of in the shaded area shown on Figure 9. The majority of the loading is associated with infiltration.

The conclusions reached are as follows:

- The contribution from inorganic area, B&H, is essentially zero.
- The current chlorobenzene discharges are insignificant when compared to the total.
- The major loading is infiltration related.

These conclusions are supported by Figures 9,10,11,12,13,14:

- At MH5-19 the loadings are essentially Not Detected (ND), thus confining B&H Area contribution.
- The loading in lines from MH5-10 to MH5-07 and MH5-12 to MH5-06 are insignificant.



LEGEND

5-04	MANHOLE
5-10	CATCHBASIN
	WASTEWATER SEWER
0.34	1980 DICHLOROBENZENES LOADING, LBS./DAY
ND	NOT DETECTED

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figure 9

DICHLOROBENZENES, 1980
005 OUTFALL
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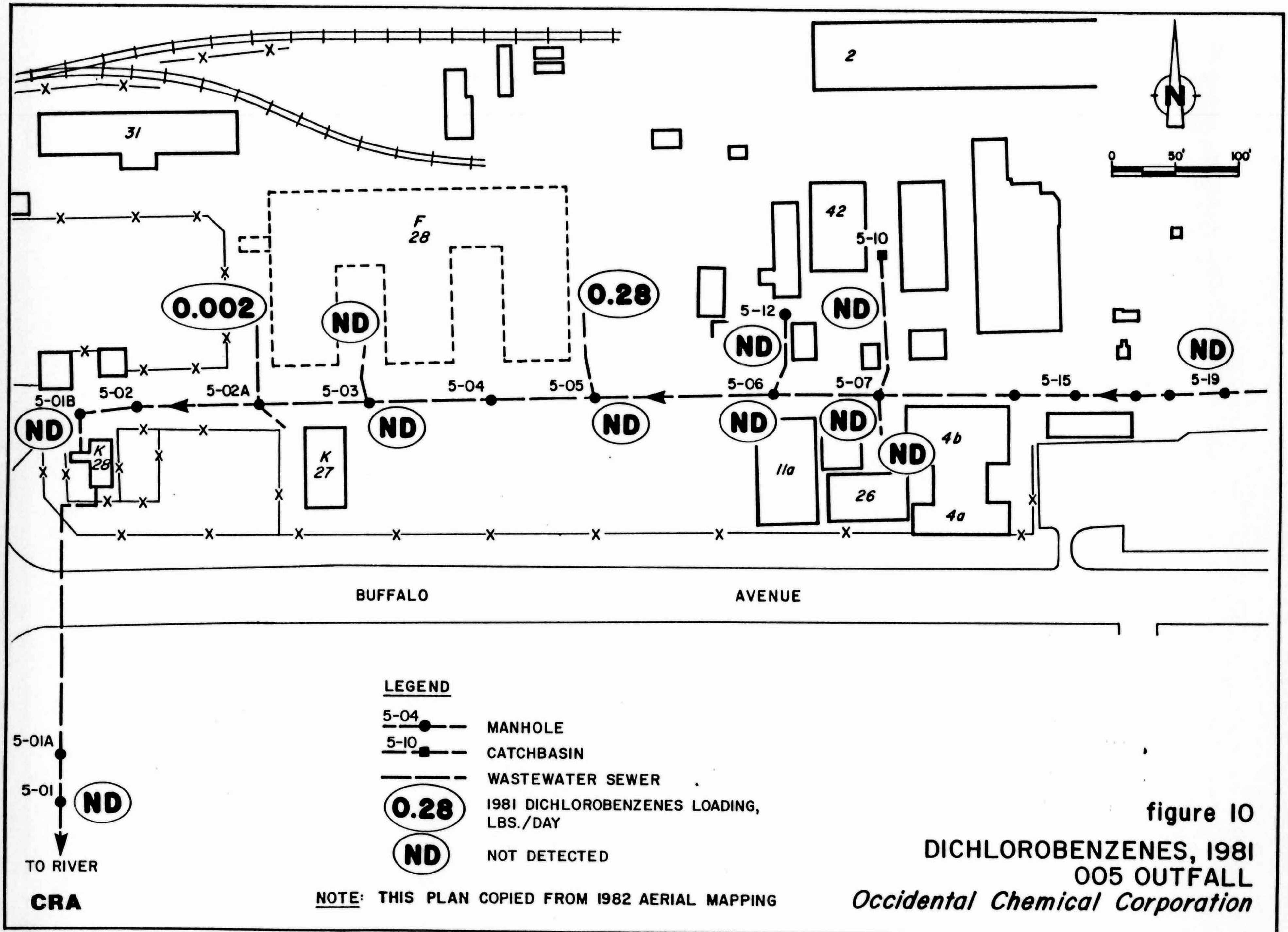


figure 10

DICHLOROBENZENES, 1981
005 OUTFALL
Occidental Chemical Corporation

1530 -12/12/84

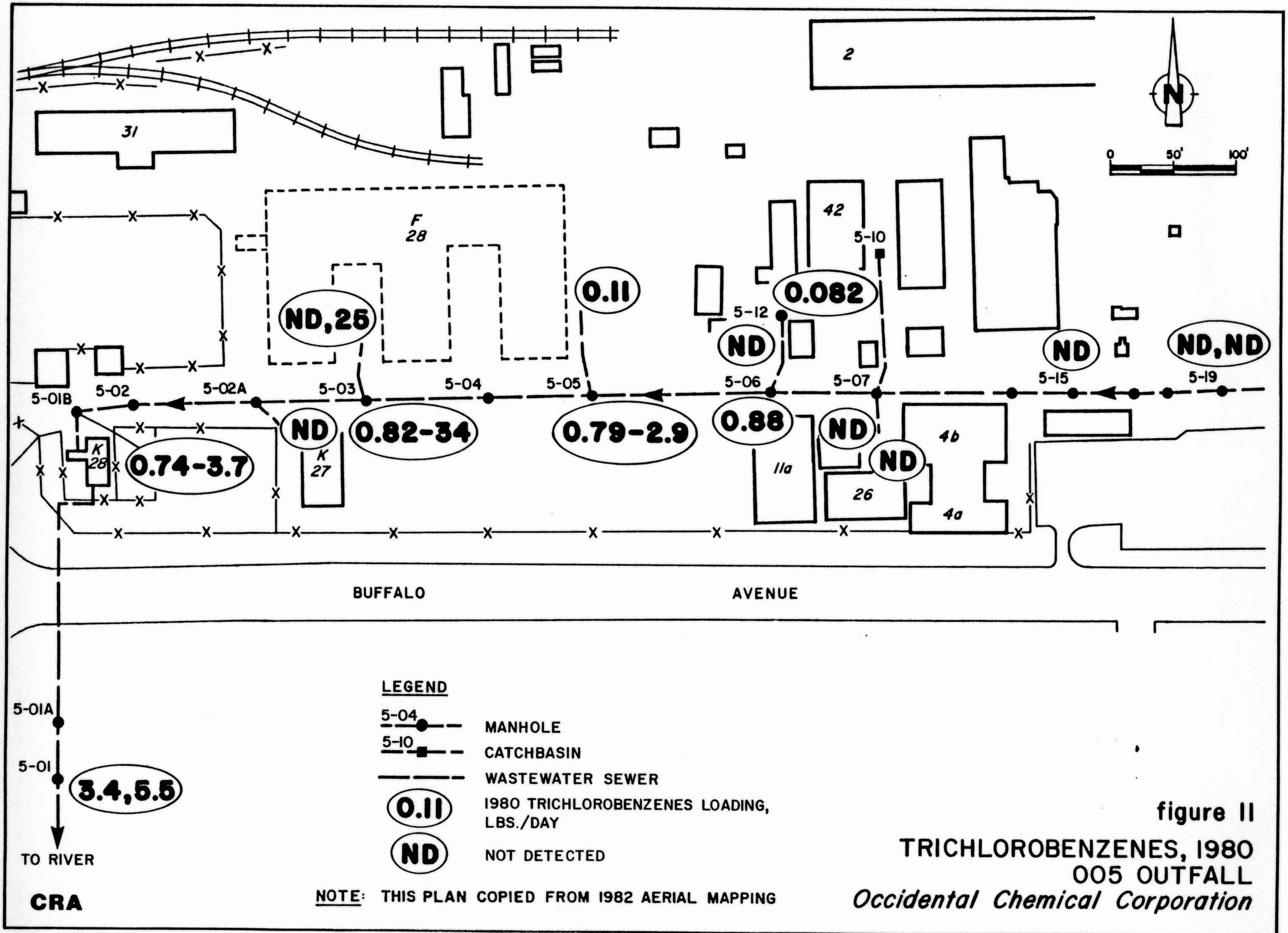


figure 11

TRICHLOROBENZENES, 1980
005 OUTFALL
Occidental Chemical Corporation

1530 -12/12/84

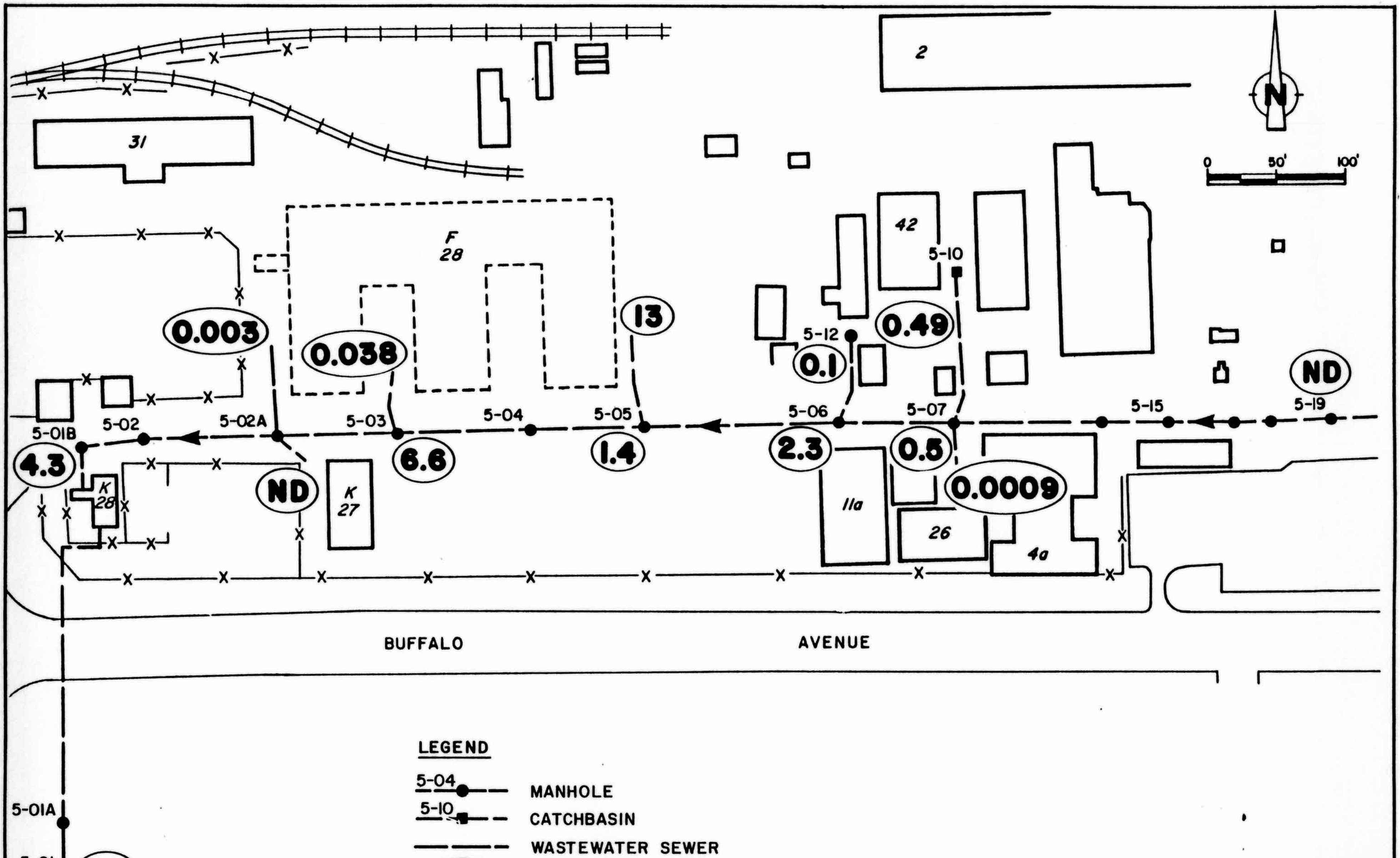


figure 12

TRICHLOROBENZENES, 1981
005 OUTFALL
Occidental Chemical Corporation

1530—12/12/84

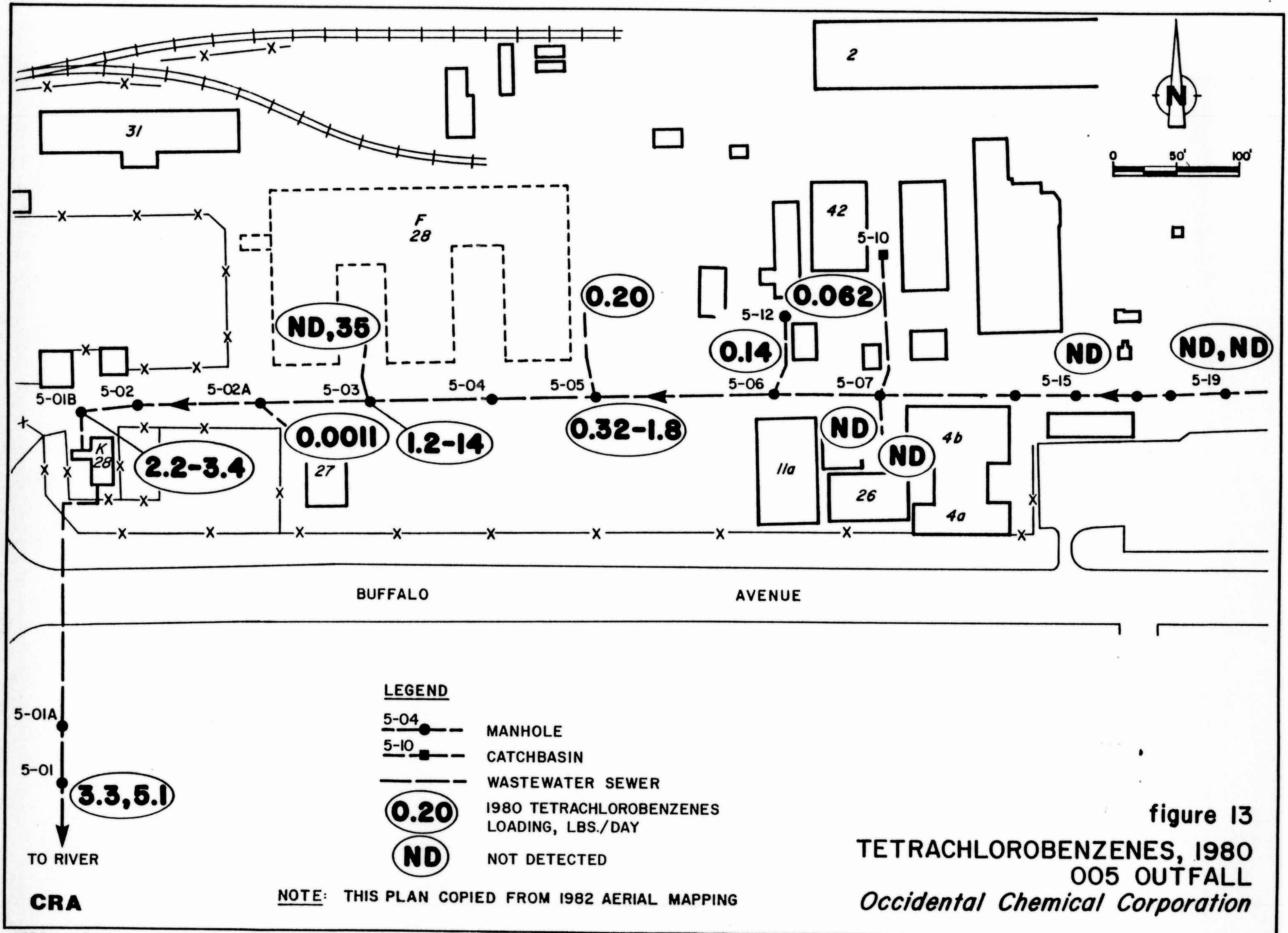


figure 13

TETRACHLOROBENZENES, 1980
005 OUTFALL
Occidental Chemical Corporation

1530 – 12/12/84

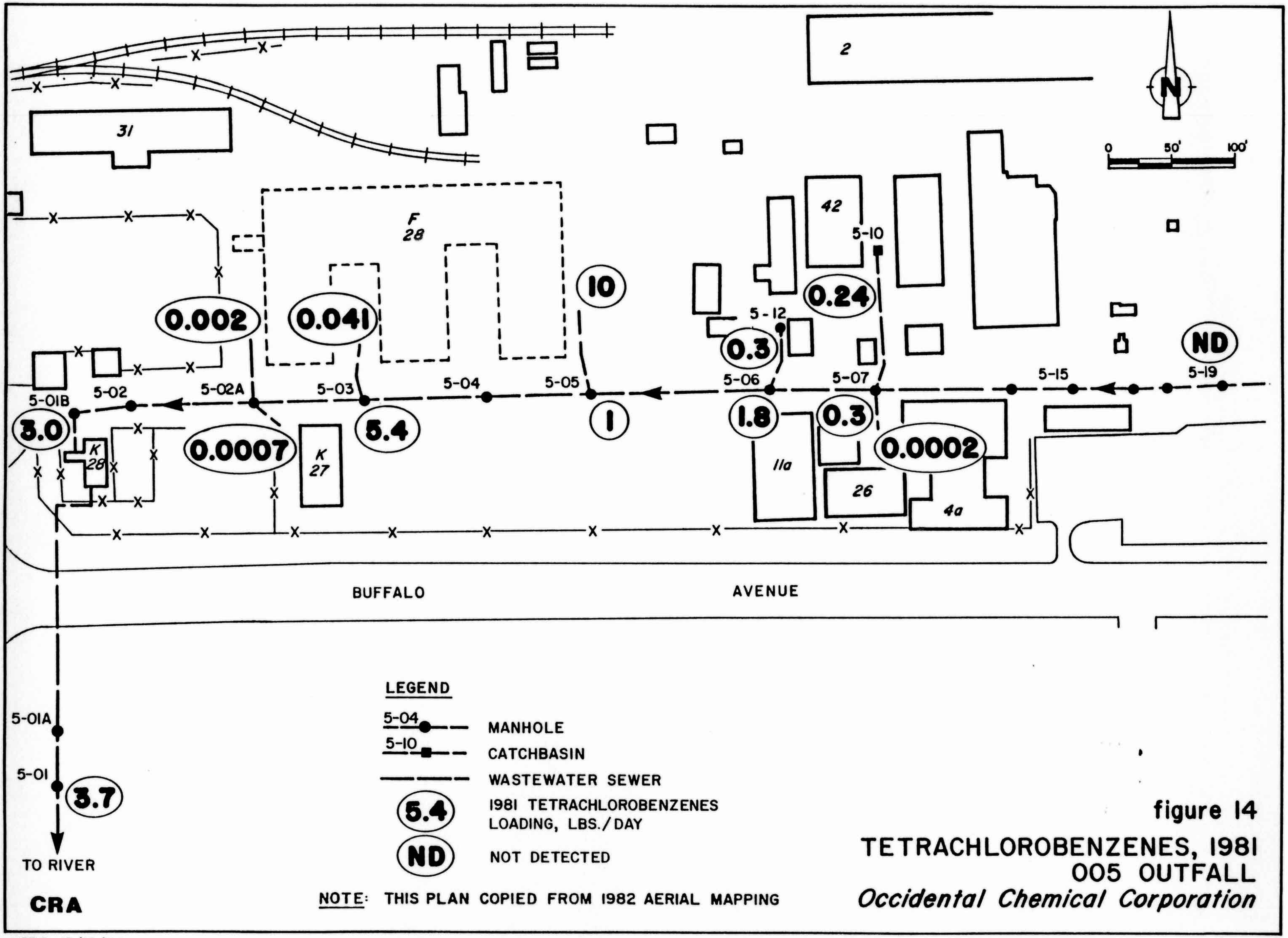


figure 14

TETRACHLOROBENZENES, 1981
005 OUTFALL
Occidental Chemical Corporation

1530 -12/12/84

- In the past, chlorinated benzenes appeared to have been infiltrating from branch lines in F-28 and into the main line sewer.

Remedial Solution

Same as described for MCT in Outfall 005 under Section 4.2.1.

4.2.3 Dichlorotoluene (DCT)

The limit for DCT was established at 8 lb/day and no reduction is required to meet the permit limit. The 1983 total average DCT loading was 1.1 lb/day with a maximum of 3.01 lb/day versus the permit limit of 8 lb/day.

4.2.4 Monochlorobenzotrifluoride (MCBTF), Dichlorobenzotrifluoride (DCBTF)

A limit of 3 lb/day was established for the discharge from S-Area lagoons in the new permit for MCT, DCT, MCBTF and DCBTF. Monitoring reports for the last year demonstrate that, as a result of process changes documented during the SPDES permit negotiations, OCC can meet these limits and that no remedial work is required.

In 1983, the average total plant MCBTF loading was 0.60 lb/day with a maximum of 1.29 lb/day, versus permit limit of 10 lb/day. The DCBTF total plant 1983 average was 0.008 lb/day with a maximum of 0.40 lb/day versus the permit limit of 3 lb/day.

4.2.5 Hexachlorocyclopentadiene (C-56)

The limit for C-56 is 1 lb/day and no reduction is required to meet the limit which was established using lognormal statistics. In 1983 our total average C-56 loading was 0.02 lb/day with a maximum of 0.21 lb/day.

4.2.6 Monochlorobenzene (MCB)

The limit for MCB is 4 lb/day based on application of a variability factor. No reduction is required. In 1983 the total average MCB loading was 0.76 lb/day with a maximum of 1.41 lb/day.

4.2.7 Toluene

The limit for toluene is 9.0 lb/day which is based on application of a lognormal statistics. No reduction is required. In 1983, the total plant average was 1.14 with a maximum of 3.61 lb/day.

4.2.8 Hexachlorocyclohexane

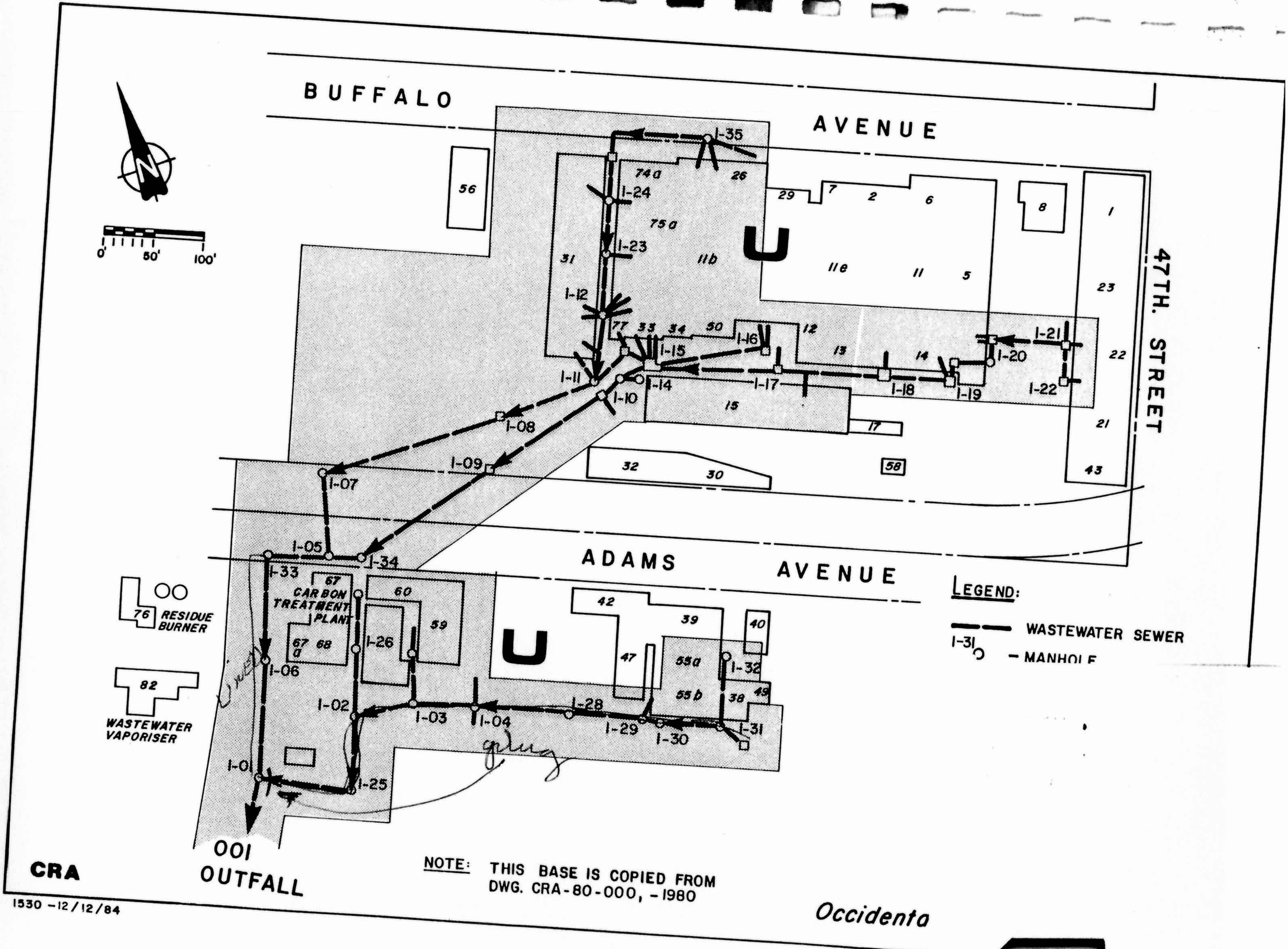
The permit limit was established at 0.26 lb/day. Currently the limit is met on an average basis but not on a maximum basis. The 1983 average was 0.17 lb/day with a maximum of 0.38 lb/day. Over 50% of the loading is attributable to Outfall 005. It is anticipated that with the work outlined for Outfall 005, a reduction of 85 percent can be achieved for the average and maximum loadings. The average and maximum would be 0.098 lb/day and 0.22 lb/day if it was assumed that 50% was infiltrating in 005 Outfall with a control factor of 85% being applied, as compared to the permit limit of 0.26 lb/day.

4.2.9 Trichloroethylene (TCE) and Tetrachloroethylene (PCE)

The limits for TCE and PCE were established at 15 lb/day. These limits were calculated using a variability factor previously described and summarized in Table 4.

Discussion of the Sources and Control for TCE & PCE

Figure 15 shows the existing 001 Outfall sewer network. The lines services the mercury cell operations in the U-31, U-75, a former potassium carbonate operation in U-55, U-15, a former TCE production area U-59. Waste treatment facilities


BUFFALO AVENUE
ADAMS AVENUE
47TH. STREET
N
0' 50' 100'
56
74a
26
75a
31
11b
29
7
2
6
8
1
11e
11
5
23
22
21
43
77
33
34
50
12
13
14
15
17
32
30
58
67
CARBON TREATMENT PLANT
67a
68
60
59
42
39
40
47
55a
55b
38
49
76 RESIDUE BURNER
82
WASTEWATER VAPORISER
I-35
I-24
I-23
I-12
I-11
I-10
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I-09
I-07
I-05
I-34
I-33
I-06
I-26
I-02
I-03
I-04
I-28
I-29
I-30
I-31
I-32
I-01
I-25
001 OUTFALL
LEGEND:
WASTEWATER SEWER
I-31 - MANHOLE
NOTE: THIS BASE IS COPIED FROM DWG. CRA-80-000, -1980
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Occidenta

1530 -12/12/84

TABLE 4

LIMITS FOR TRICHLOROETHYLENE AND TETRACHLOROETHYLENE

	CURRENT LEVELS			REDUCTIONS		ANTICIPATED LOAD		
	Arithmetic Mean Column #1	High Value (of 22 data Points) Column #2	RATIO (High Value / Mean) Column #3	Potential Reduction (Mean) Column #4	Calculated (Projected) Reduction (Mean) Column #5	(Column #1 Minus Column #5) Column #6	(Column #6 Times Column #3)	BAT Limit
Trichloroethylene	8.82	42.91	4.86	6.8	5.8	3.02	14.7	15
Tetrachloroethylene	5.90	22.13	3.75	3.6	3.0	2.9	10.9	11

(Above values are mass loadings [pounds per day]) are located in U-67 area. Several sampling programs were conducted in the past and the following conclusions were reached with respect to TCE and PCE:

- The contribution from the mercury cells and carbonate process areas is essentially zero.
- The major loading is associated with infiltration of these materials from the former TCE operations.

These conclusions are supported by:

Figures 16 to 19 A-D in 1980 and 1981 show the following:

1. At MH33 the contributions from the mercury cell operations are essentially not detected (ND).
2. From MH04 to MH01 contain the majority of the loadings associated with infiltration.
3. The overburden flow is from a northeast to southeast direction. The area appears contaminated with TCE and PCE as evidenced by monitoring well results.

Remedial Solutions

Potassium carbonate operations in U-55 have been terminated thus the need to service this area with cooling water has been negated. With this in mind, the sewer line from MH1-01 to MH1-31, which is the source of the loading, can be abandoned. The line will be permanently plugged at the east side of MH1-01.

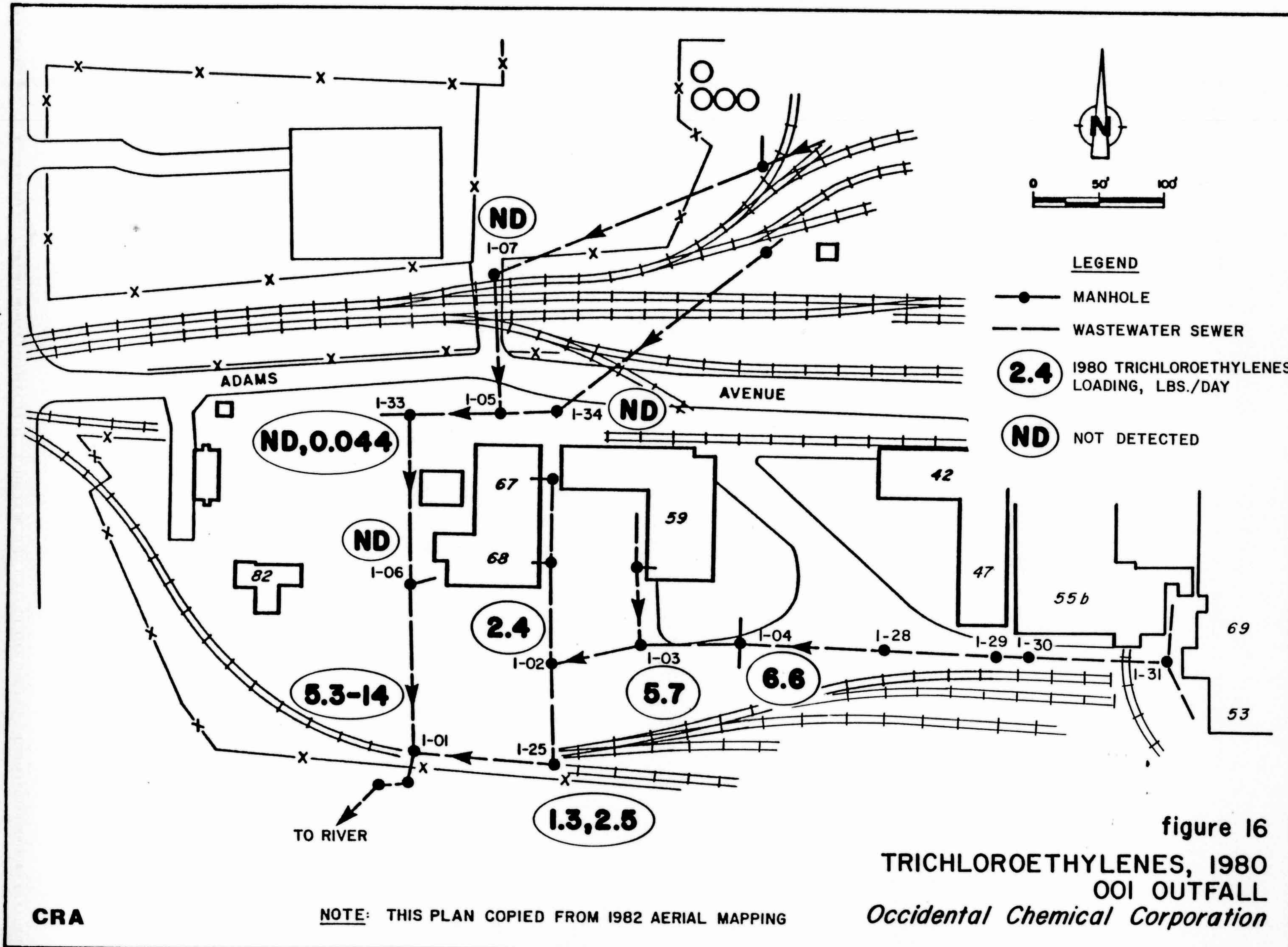

figure 16

TRICHLOROETHYLENES, 1980
001 OUTFALL
Occidental Chemical Corporation

1530 -12/12/84

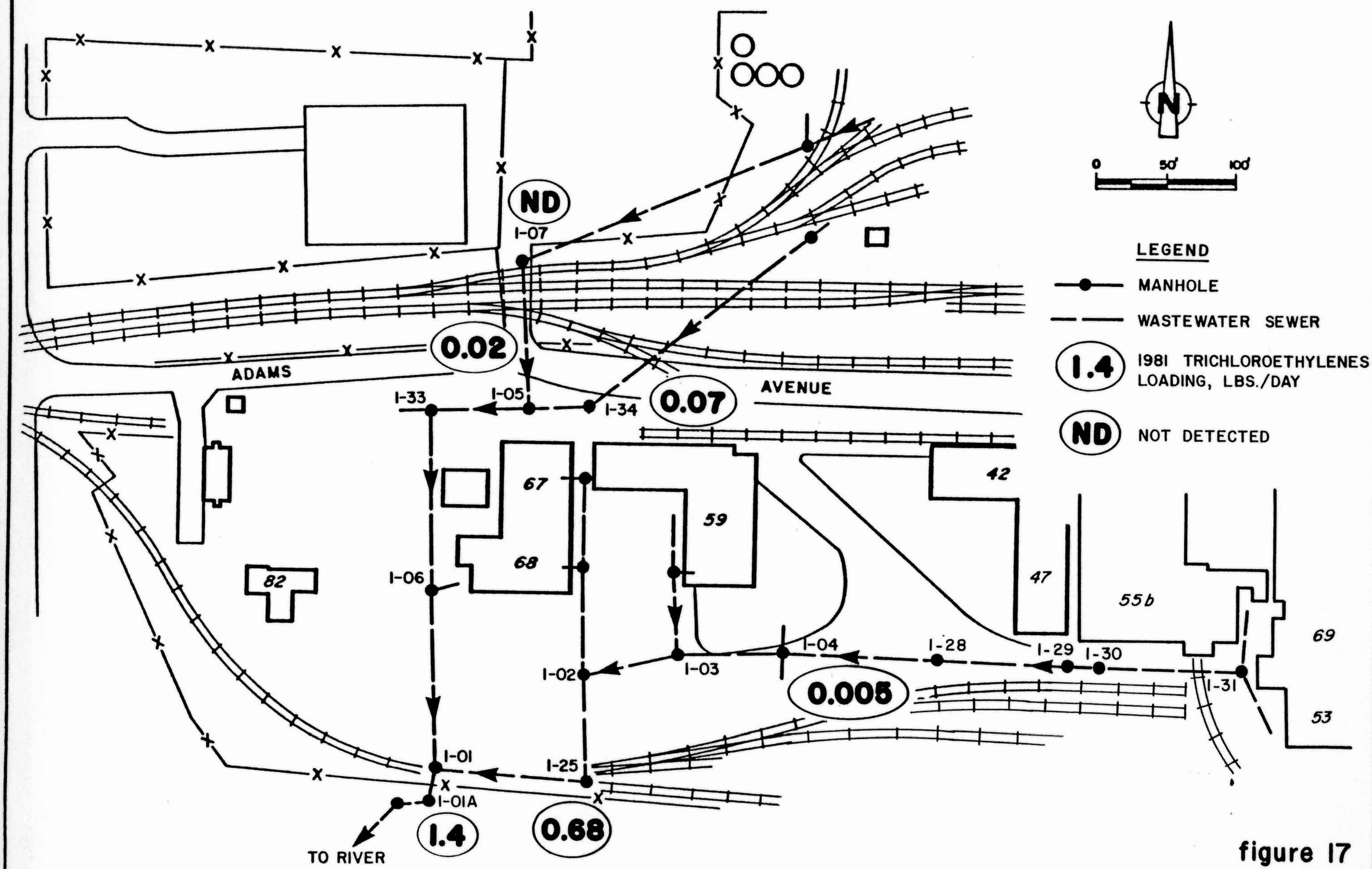

figure 17

TRICHLOROETHYLENES, 1981
001 OUTFALL
Occidental Chemical Corporation

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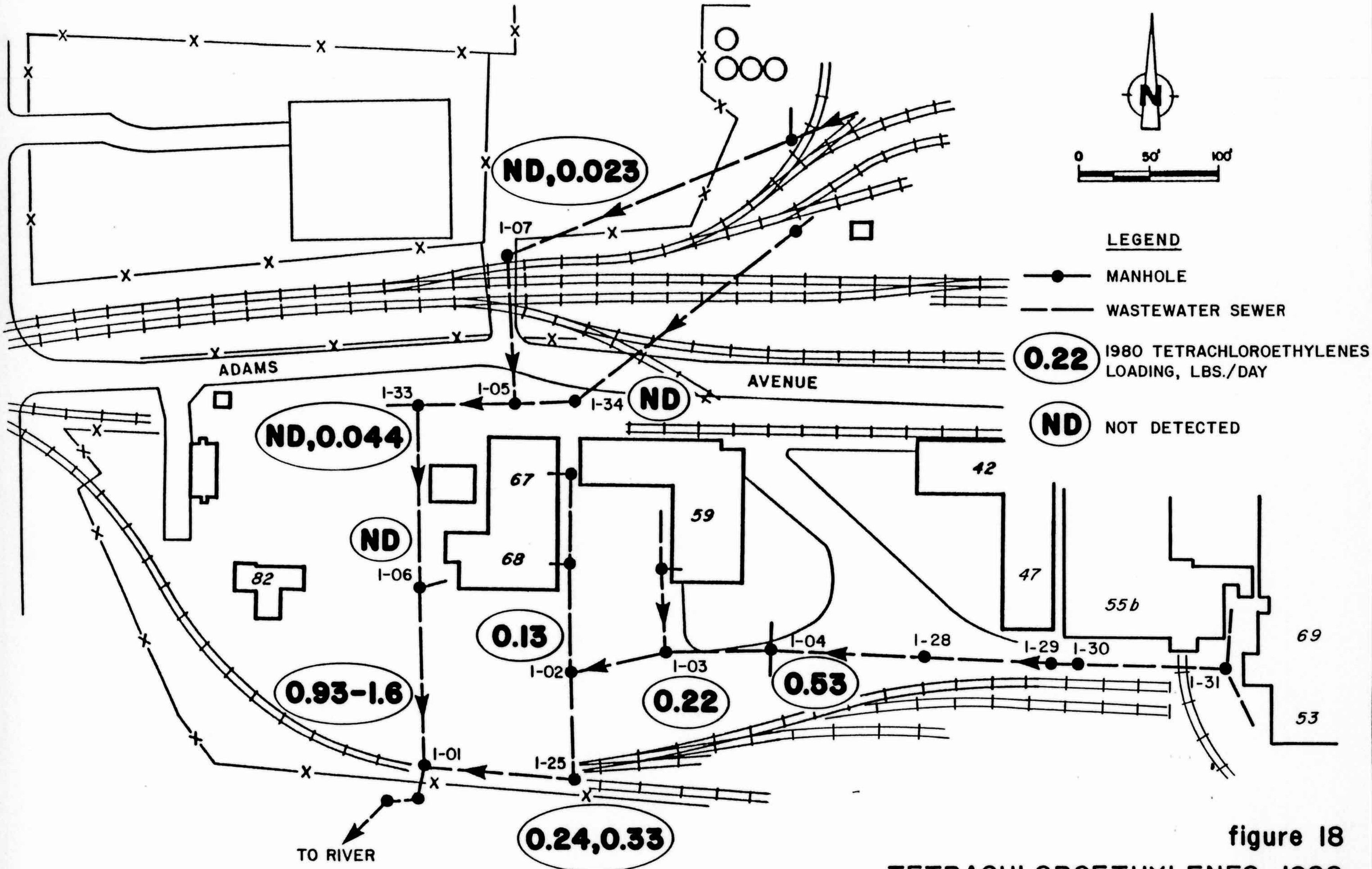

figure 18

TETRACHLOROETHYLENES, 1980
001 OUTFALL
Occidental Chemical Corporation

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1530 -12/12/84

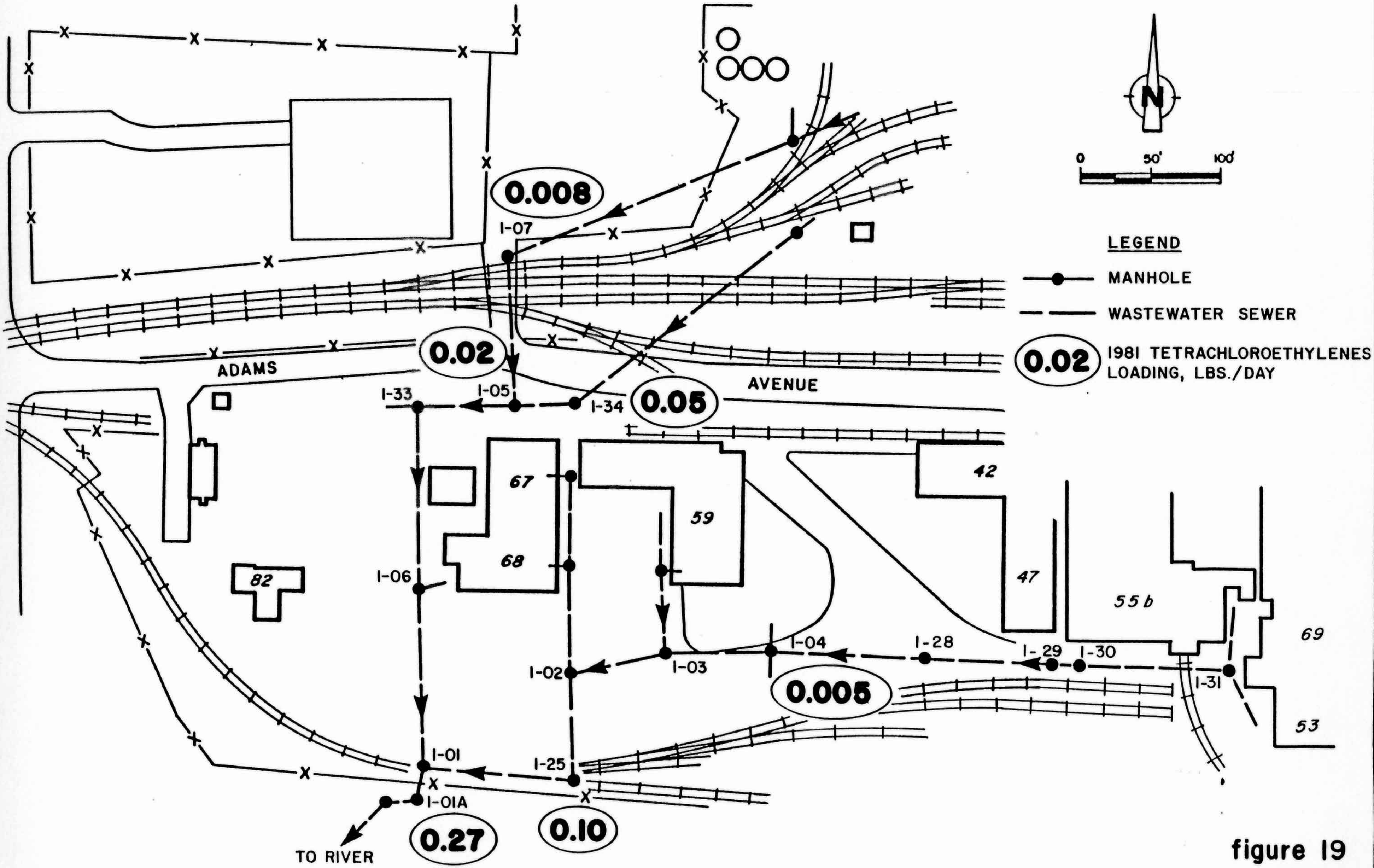

figure 19

TETRACHLOROETHYLENES, 1981
001 OUTFALL
Occidental Chemical Corporation

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NOTE: THIS PLAN COPIED FROM 1982 AERIAL MAPPING

By permanently abandoning the sewer line, an 85% reduction in PCE/TCE is being anticipated. Details are provided in a later section.

Although not required to meet permit limits, the cleaning and lining of the sewer from MH1-01 to MH1-33 will be included as part of this project.

5.0 pH OUTFALL 001

Historically at infrequent intervals, the pH in Outfall 001 was above 9.0. Some of these occurrences were traced to operational problems but others were thought to be associated with infiltration. With the shutdown of the mercury cell plant and carbonate process, water discharges have been drastically reduced to the current level of 600,000 gal/day. This level of flow is maintained in the sewer to ensure adequate pH control. To determine if the problem is related to infiltration, the intention is to temporarily reduce the water flow and sample each branch sewer. We anticipate performing this analysis during wet and dry weather seasons. After data collections are reviewed, a separate report will be submitted to DEC on the findings.

6.0 ENGINEERING ASPECTS AND WORK PLAN OUTFALL 001 AND OUTFALL 005

6.1 RELINING OF SEWERS

Occidental is investigating two types of sewer relining techniques. The first is Insituform lining (see Appendix A). This technique is described in the attached information from the applicator/manufacturer. An impregnated resin liner is formed within the existing sewer line.

The second technique involves lining the sewer with a pipe made of polyethylene or other compatible type of material. This technique involves the insertion of a smaller diameter pipe inside an existing sewer line.

To prevent/minimize infiltration, the manholes will be made watertight and the number of manholes and connections will be kept to a minimum.

6.2 REMEDIAL WORK FOR OUTFALL 005

6.2.1 Existing Conditions

The existing outfall sewer system in the "F" and "K" Areas is shown on Figure 20. This is the portion of the 005 system where remedial work will occur.

6.2.2 Relining Work

The 42-inch outfall sewer from MH 5-19 to MH 5-01B will be relined.

The liner will be continuous through the following manholes: MH5-17, MH5-16, MH5-15, MH5-08, MH5-05, MH5-04, MH5-02A and MH5-02.

The two 15-inch sewers in the Building F-10 area from MH5-12 to MH5-06 and from MH5-10 to MH5-07 are currently being studied for future use and may be permanently abandoned and plugged. If they remain active they will be relined.

The primary concerns that will govern liner selection are resistance to infiltration, resistance to

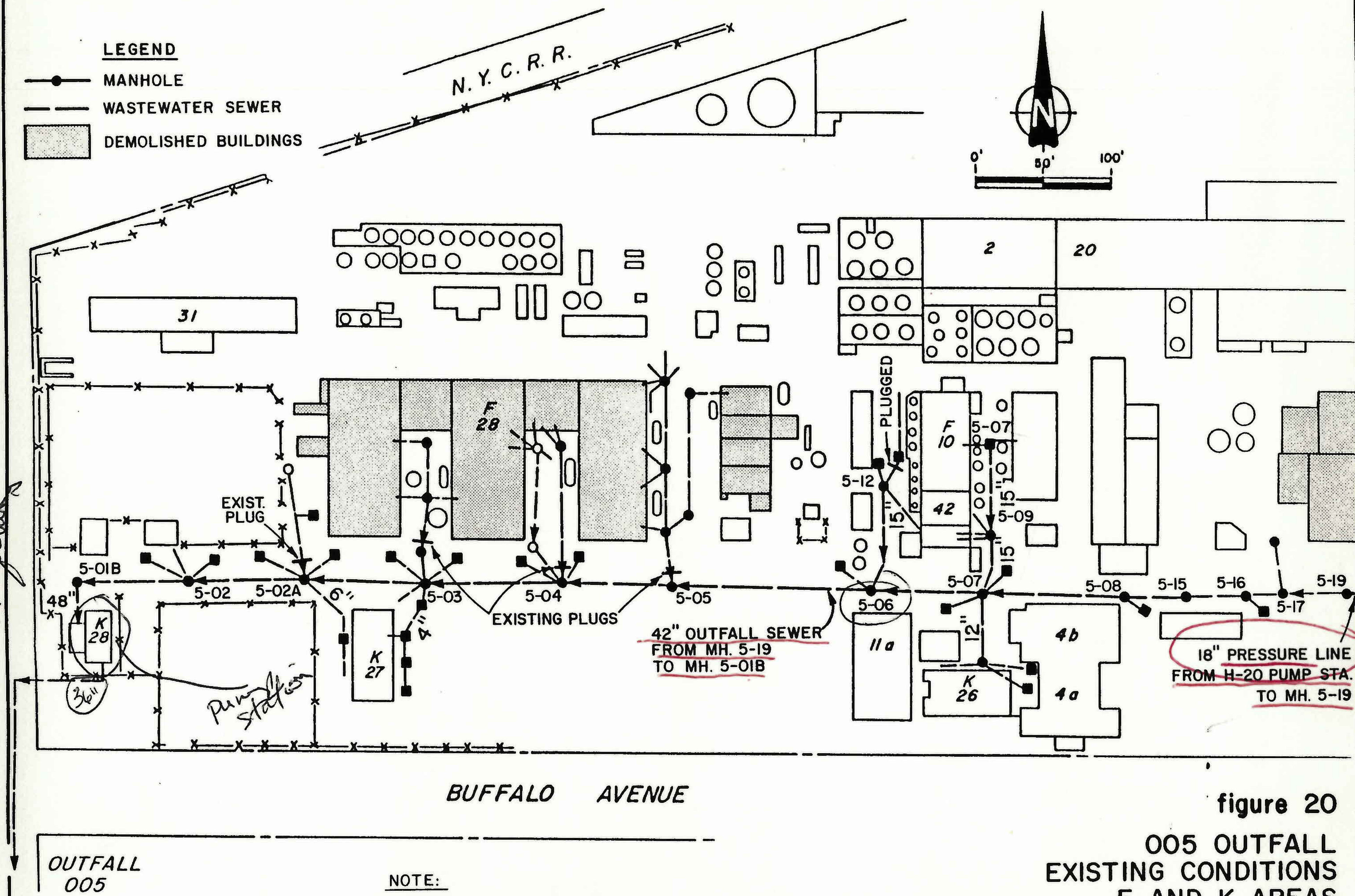

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figure 20

005 OUTFALL
EXISTING CONDITIONS
F AND K AREAS
Occidental Chemical Corporation

1530 -12/12/84

attack from chemicals in groundwater, structural integrity, minimum installation time and minimum excavation requirements.

6.2.3 Manholes

The continuous liner through manholes MH5-17, MH5-16, MH5-15, MH5-08, MH5-05, MH5-04, MH5-02A and MH5-02 will eliminate any flow or infiltration into the 42-inch outfall sewer at these manholes. Existing catch basins which flow into these manholes must be diverted into the adjacent sanitary sewer or abandoned. All other lines entering these manholes will be abandoned.

Manholes MH5-19, MH5-07, MH5-06 and MH5-03 will be repaired around existing pipes and relined or repaired to eliminate infiltration.

Manhole 5-01B is a poured in-place reinforced concrete chamber which is structurally sound and without any discernible infiltration. No remedial work is required on this manhole.

6.2.4 Other Active Lines

The 12-inch line from Building K-26 and the 4-inch line from Building K-27 will remain active. No remedial work is planned for these lines.

6.3 REMEDIAL WORK FOR OUTFALL 001

6.3.1 Existing Conditions

The existing outfall sewer system in the "U" Area is shown on Figure 21.

6.3.2 Relining Pipe

The 36-inch outfall sewer from MH1-33 to MH1-01 will be relined. No other relining is planned in this area.

6.3.3 Repairing of Manholes

Manholes MH1-01 and MH1-06 will be repaired.

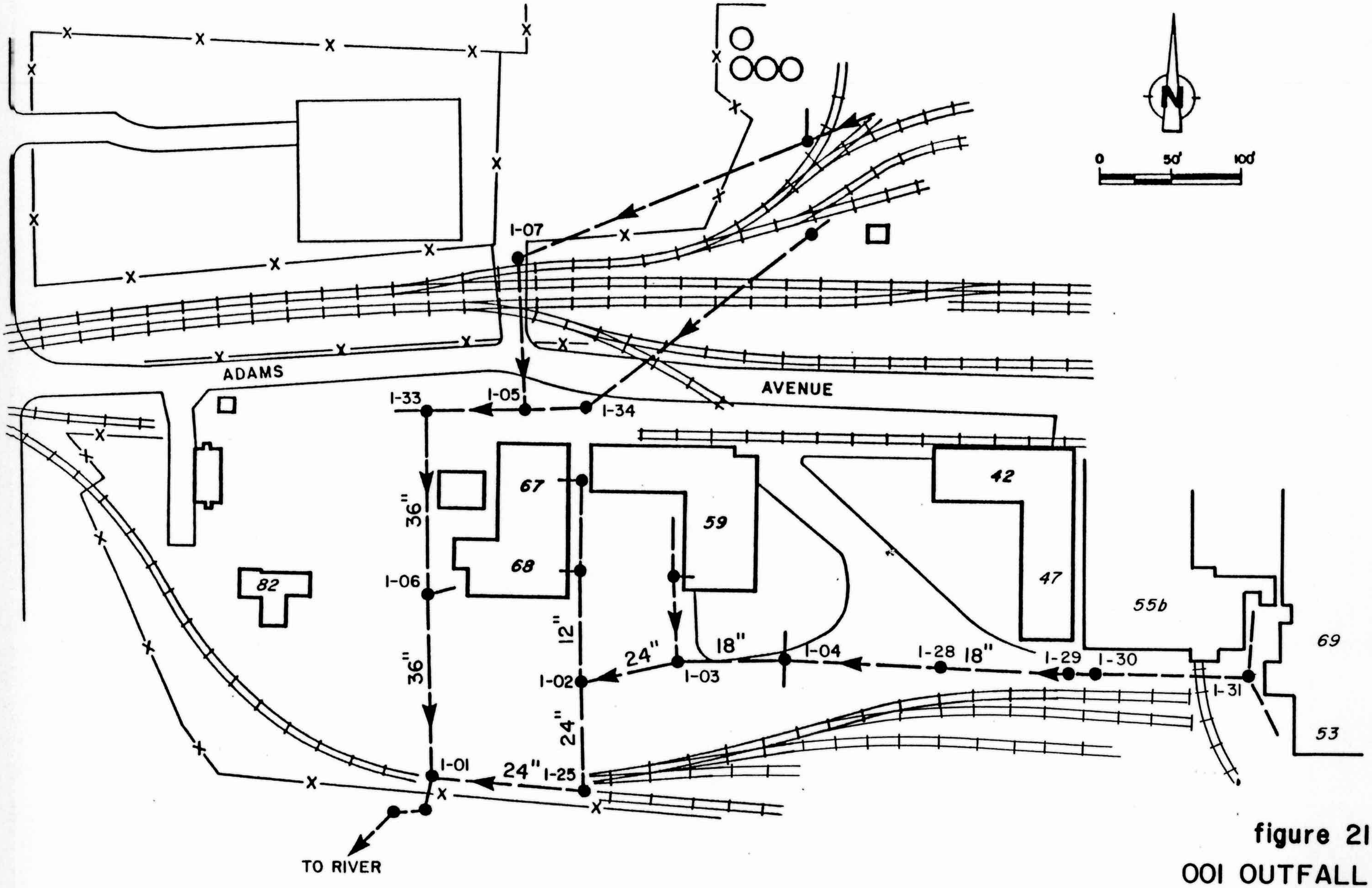

figure 21

OOI OUTFALL
EXISTING CONDITIONS
U AREA
Occidental Chemical Corporation

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6.3.4 Sewer Abandonment

The entire sewer system from MH1-31 to MH1-01 will be abandoned. The 24-inch sewer will be plugged on the east side of MH1-01.

6.4 CLOSURE OF OUTFALL 002

Outfall 002 was abandoned on 12/27/82. This was documented in our December 1982 SPDES report.

Since the spring of 1984, Outfall 002 waters were used as makeup waters on a volume offset for the N/S Area treatment system. We propose to continue this philosophy by utilizing a new watertight surface/cooling water drainage system for the N-Area. The water from this system is being pumped into a settling tank for precautionary purposes and discharged to Outfall 003 by way of the N/S neutralization system.

DMR's submitted since this practice have shown no adverse affects in 003-S loading, and it is anticipated that the future 3.0 lb/day 003-S loading limitations will be met.

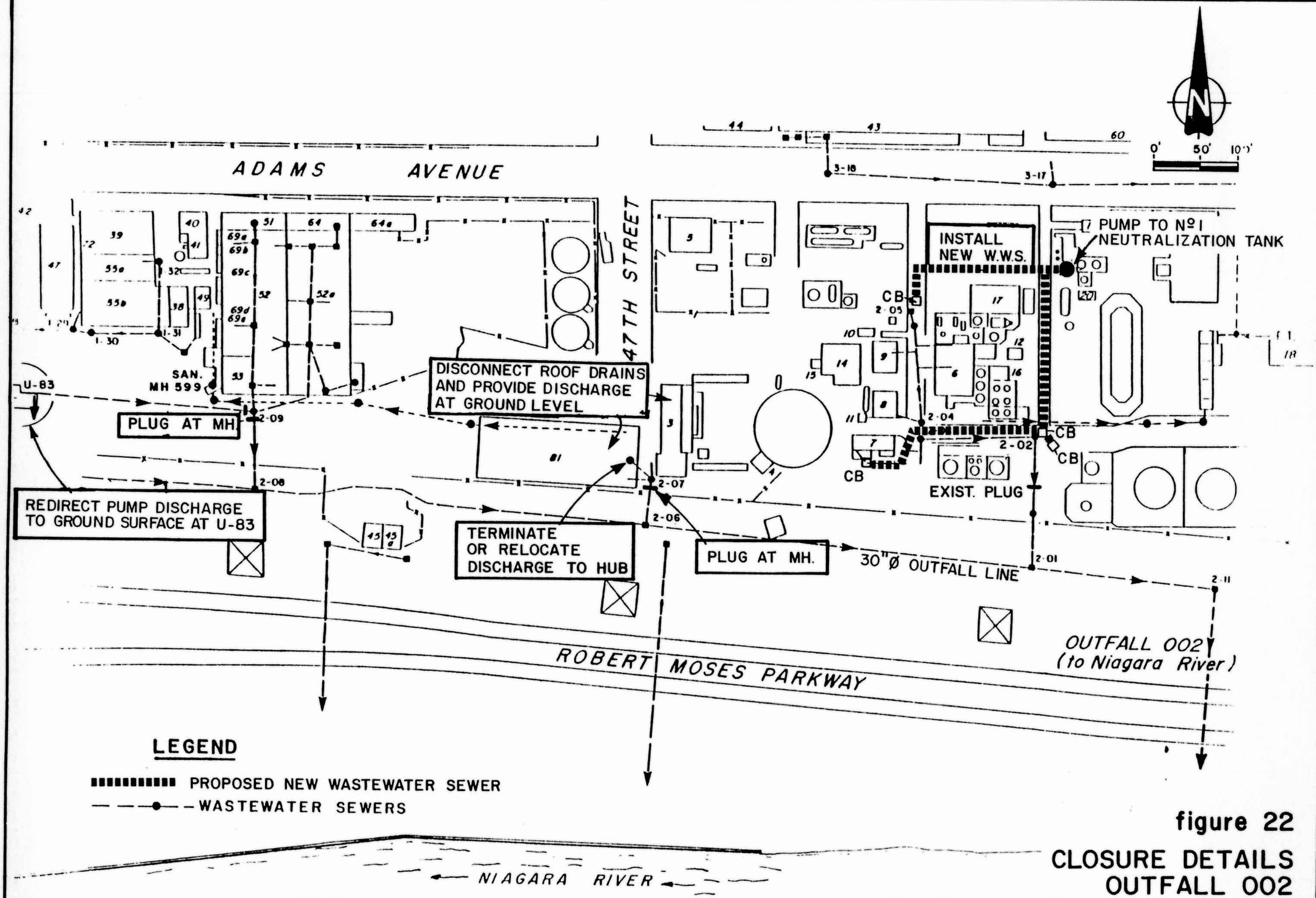

figure 22

CLOSURE DETAILS
OUTFALL 002
Occidental Chemical Corporation

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1530 · 12/12/84

An alternate was investigated which would have routed the water through a portion of 003 Outfall but this option was not selected since the particular section in mind was abandoned a number of years ago and if reopened might increase loading. As a BMP, it was felt that pumping the water through a tank as currently practised, would provide a line of defense against unplanned circumstances. It should be noted that most of the N-Area is diked and that process water passes through an API separator before discharge to the sanitary sewer. The work planned is shown in Figure 22.

Plugs

A plug has been installed on the "N" area outfall line between MH2-02 and MH2-01.

New plugs will be installed on the "U" area outfalls south of MH2-09 and MH2-07.

Diversions

Roof drains will be directed to discharge at ground level at Buildings U-81 and N-3.

Discharges to hub drain at east end of Building U-81 will be terminated or relocated inside the building.

Pump discharge at the weigh scale building U-83 will be redirected to the ground. Currently, before caustic is shipped by rail, it is weighed. The weigh scale at U-83 is utilized for weighing. Surface water runoff from the weigh scale building will be directed to the ground surface.

APPENDIX A

INFORMATION ON INSITUFORM LINING

INSITUFORM
OF NORTH AMERICA, INC.

Dear Inquirer:

Thank you for your inquiry into the Insituform Process - molding a new pipe within the old, on site. Briefly, here are just a few of the benefits that you, your customers, and your users will realize from this unique process of pipeline rehabilitation.

Virtually eliminates excavating problems. Depending on the situation and existing access (sewer manholes, for example), excavation is virtually eliminated, giving you quicker, safer, more convenient repairs. No threats to existing utilities. No interruptions of traffic flow.

Restores full size capacity and reduces maintenance. Insituform fits tight and is extremely smooth and continuous over pipe joints, reducing deposits and almost always increasing capacity.

Tailored to your need. Various thermosetting resins can be selected to resist the corrosive effects of the effluent. Insituform fits unusually shaped pipes and has been used in sizes from 4" to 108" (and may be applicable to other sizes).

Solves difficult jobs. Insituform is applicable to pipelines with bends, lines vertical wells, pressure pipe, or pipelines with reducers.

All in all, the Insituform Process is easy, safe and reliable. For more information, please review the attached material. We are certain you will agree that Insituform is the better method of pipeline rehabilitation. We have some very interesting case histories.

If you would like to discuss the Process for a particular application, or if you need further information, please contact me or our licensee in your area if referenced below.

Thank you again for your inquiry.

Cordially,

INSITUFORM OF NORTH AMERICA, INC.

Edward W. Stephenson

Edward W. Stephenson
Marketing Coordinator

Attachments

NOV 13 1984
ENVIRONMENTAL CONTROL
NIAGARA PLANT

3315 Democrat Road/P.O. Box 181071/Memphis, TN 38118/TELEX 810-591-1252/Phone 901-363-2105

INSITUFORM™

REHABILITATES DAMAGED PIPES AT A FRACTION OF REPLACEMENT COSTS!

BEFORE AFTER

INSITUFORM

DESIGN GUIDE

FOR PIPELINE RECONSTRUCTION

Before

After

HOW INSITUFORM® WORKS

Insituform® is a unique method of pipeline reconstruction which not only can seal and preserve pipeline, but can also be designed to make structural repairs of the pipe, if necessary. The reconstruction is done through existing pipe access points, usually in twenty-four (24) hours or less, and in most cases requires no excavation.

The Insituform® process is basically very simple. A fiberfelt tube impregnated with a liquid resin is fed into an inversion standpipe which has been erected on site. The felt tube has an impermeable coating on the outside which eases handling and provides a water barrier for the inversion process.

The end of the tube is pulled through the inversion standpipe, turned inside out and clamped to the standpipe such that a leak-proof seal is established.

As more water is added to maintain the weight of the column, additional tubing is fed into the standpipe, and the impregnated tube snakes its way forward through the pipe being rehabilitated.

The weight of the water presses the coated felt at the nose, inverts it, and then presses the resin impregnated side hard against the insides of the damaged pipe, leaving the smooth coated side as the new interior surface of the rehabilitated pipe. After the inverted tube reaches the next manhole or other access point, the water is heated to cure the resin, forming an impermeable new pipe within the old. The ends are cut off, the head of water is released and the Insituform® operation is complete.

Service connections are reinstated in non-man entry pipes by means of a remotely controlled cutting device.

ADVANTAGES OF INSITUFORM®

Insituform® tubes when inserted are flexible sleeves and, therefore, are not limited to circular pipes. They take the shape of the conduit being rehabilitated and can vary in equivalent diameters from 4 inches (102mm) to 108 inches (2,704mm).

The inversion process allows the impregnated felt tube to easily negotiate offset joints and pipe bends of 45 degrees. The buoyant effect of the water suspends the uninverted tube in a frictionless media enabling it to traverse over 2,000 feet (609m).

Insertion is made through existing pipe access points. Service connections are readily reestablished from within, thus eliminating costly excavation and restoration.

The tubing, when cured in place, forms a continuous sleeve throughout, sealing the pipeline.

The thermosetting resins resist corrosion and protect the pipeline materials.

The tight fitting Insituform® pipe minimizes loss in cross sectional areas which because of improved smoothness results in increased hydraulic capacity.

Insituform® is a total reconstruction process, usually completed in one (1) day thus saving time and reducing downtime, inconvenience to commerce and the public.

INSITUFORM® DESIGN GUIDE

The information presented in this guide is condensed from a more comprehensive booklet of Insituform® Design, which is available on request. The design information is based on tests performed in the United States and Great Britain, and extensive experience in the installation of Insituform®. The use of this guide should be incorporated along with good engineering design practices and judgment.

Insituform® is a registered trademark of Insituform of North America, Inc.

FLOW CHARACTERISTICS

Insituform® usually improves flow capacity. The increase in capacity is due to smooth transitions at offsets and protrusions, no joints between manholes, and a smoother surface.

The traditional Manning equation can be used to determine specific flow rates by substituting appropriate values for before and after conditions. Coefficient (n) values of Insituform are 0.008 to 0.010.

$$Q = \frac{1.486}{n} \times AR^{2/3} \times S^{1/2}$$

Q = Flow (cfs)
A = Flow Area of Pipe (sq. ft.)
n = Manning Coefficient
R = Hydraulic Radius (ft.) = D/4
S = Slope (ft./ft.)

CAPACITY IMPROVEMENTS FOR INSITUFORM® IN VITRIFIED CLAY AND CONCRETE PIPES

Diameter (inches)	Slope (ft./ft.)	Flow V.C.P. #1 (cfs)	Flow Conc. #2 (cfs)	Flow Insituform® #3 (cfs)	Insituform® Thickness (mm)	Insituform® Line I.D. (inches)	FLOW CAPACITY (%) Insituform® vs. V.C.P.	Insituform® vs. Conc.
8.00	.004	0.77	0.67	0.94	6.00	7.528	123	142
10.00	.0028	1.17	1.01	1.48	6.00	9.528	127	146
12.00	.0022	1.69	1.46	2.19	6.00	11.528	130	150
15.00	.0015	2.53	2.19	3.33	7.50	14.409	130	150
18.00	.0012	3.67	3.18	4.77	9.00	17.291	130	150
21.00	.0010	5.06	4.39	6.50	10.50	20.173	130	150
24.00	.0008	6.47	5.61	8.39	12.00	23.055	130	150
27.00	.00067	8.11	7.03	10.40	13.50	25.937	130	150
30.00	.00058	9.99	8.66	12.82	15.00	28.819	130	150
36.00	.00046	14.48	12.55	18.56	18.00	34.583	130	150

NOTES: 1. "n" for V.C.P. = 0.013 2. "n" for Conc. = 0.015 3. "n" for Insituform® = 0.009

INSITUFORM® DESIGN FOR EXTERNAL HYDROSTATIC LOADINGS

The tables and formulae below are based on the assumption that although the existing pipe has longitudinal cracks and some distortion, the adjacent ground will give adequate support to pipe and Insituform®.

Hydrostatic loading on Insituform® will be considered for the following cases: (a) circular or slightly oval sound pipe; (b) deformed sound pipe, taken as flat on an otherwise circular liner; (c) pipe with a segment missing.

(a) Circular or Slightly Oval Pipe

Restrained Buckling

$$\text{Max } p = \frac{2KE}{(1-\nu^2)} \frac{1}{(SDR-1)^3} \frac{C}{N}$$

Max p = Safe Design Pressure (psi)
E = 150,000 psi Long Term Flexural Modulus
ν = 0.3 Poisson's Ratio
$SDR = \frac{\text{(Mean Outside Diameter of Insituform®)}}{\text{(Mean Insituform® Thickness)}}$
C = Table No. 1 Ovality Reduction Factor

N = 2 Safety Factor
K = 7 Insituform Enhancement Factor
q = Table No. 1 Ovality in
σ = 3,000 psi Flexural Stress

(b) Pipes with Flats

Pressure Limited Due to Stress

$$\frac{\sigma}{N} = 0.469\left\{\frac{L}{D}\right\}^{1} (SDR)^{5}\,\frac{P^2}{E} - 0.750\left\{\frac{L}{D}\right\}^{2} (SDR)^{2}\, p$$

Pressure Limited Due to Deflection of Flat

Deflection limited to 3% of L

$$\frac{L}{D} = \frac{\text{Length of Flat}}{\text{Mean Diameter of Insituform®}}$$

$$p = \frac{0.192\,E}{(SDR)\left\{\frac{L}{D}\right\}}$$

(c) Pipes with Segment Missing

Pressure* Limited Due to Buckling

$$p^* = \frac{2E}{3(1-\nu^2)} \frac{1}{(SDR-1)^3} \frac{1}{N}\left[\left\{\frac{360}{\nleftrightarrow}\right\}^2 - 1\right]$$

$\nleftrightarrow$ = angle in degrees of Missing Segment subtended at the center of the pipe.

p^* = Safe design pressure (psi) due to saturated soil.

$$= \frac{(120\text{ lb/ft}^3\text{ Saturated Soil Density})(\text{Depth of bury in ft.})}{144\text{ in.}^2/\text{ft.}^2}$$

NOTE: For $\nleftrightarrow$ equal to less than 60° check for (a) Restrained Buckling.

TABLE NO. 1

Ovality % q	0	1.0	2.0	4.0	5.0	6.0	8.0	10.0
Factor C	1.0	.91	.84	.70	.64	.59	.49	.41

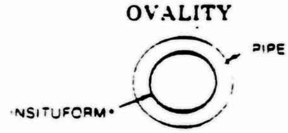
NOMINAL SPECIFIED INSITUFORM® THICKNESS† REQUIRED BASED ON EXTERNAL PRESSURE AND THREE SHAPE FACTOR CONSIDERATIONS*

	0' – 8' DEPTH		8.1' – 12' DEPTH		12.1' – 16' DEPTH		16.1' – 20' DEPTH		20.1' DEPTH		24.1' DEPTH	
Exist. Pipe I.D.	Minimum Design Thickness (Inches)	Specified Insituform® Thickness (MM)	Minimum Design Thickness (Inches)	Specified Insituform® Thickness (MM)	Minimum Design Thickness (Inches)	Specified Insituform® Thickness (MM)	Minimum Design Thickness (Inches)	Specified Insituform® Thickness (MM)	Minimum Design Thickness (Inches)	Specified Insituform® Thickness (MM)	Minimum Design Thickness (Inches)	Specified Insituform® Thickness (MM)
6"	.091	3	.103	3	.113	4.5	.122	4.5	.129	4.5	.136	4.5
8"	.121	6	.138	6	.151	6	.163	6	.173	6	.182	6
10"	.151	6	.172	6	.189	6	.204	6	.216	7.5	.227	7.5
12"	.181	6	.207	6	.227	7.5	.244	7.5	.259	7.5	.273	9
15"	.226	7.5	.258	7.5	.284	9	.305	9	.324	10.5	.341	10.5
18"	.271	9	.310	9	.341	10.5	.366	10.5	.389	12	.409	12
21"	.317	9	.362	10.5	.398	12	.428	13.5	.454	13.5	.477	13.5
24"	.362	10.5	.413	12	.454	13.5	.489	15	.519	15	.545	16.5
27"	.407	12	.465	13.5	.511	15	.550	16.5	.583	16.5	.614	18
30"	.452	13.5	.517	15	.568	16.5	.611	18	.648	19.5	.682	19.5
36"	.543	16.5	.620	18	.681	19.5	.733	21	.778	22.5	.818	24
42"	.633	18	.724	21	.795	22.5	.855	25.5	.908	27	.954	27
48"	.724	21	.827	24	.909	25.5	.977	28.5	1.037	30	1.091	31.5
54"	.814	24	.930	27	1.022	30	1.099	31.5	1.167	33	1.227	34.5
60"	.905	25.5	1.034	30	1.136	33	1.222	34.5	1.297	37.5	1.363	39

*The above chart is based on an open channel Insituform® pipe subjected to an **external static water head, equal to the total depth** and shape factors of no worse condition than an ovality of 2%, a flat in the circumference no greater in width than 20% of the diameter, and no missing segment of pipe greater than an angle of 60° on the circumference. The design is based on a cured thermoset Insituform® with a Modulus 'E' of 300,000 psi and long term behavior being taken into account by using a lower value to allow for creep. NOTE: The table recommends an Insituform® thickness based upon the fiberfelt tubes currently manufactured. The thickness of Insituform® after curing is dependent upon the condition of the pipe and the resin used; it is expected to exceed the minimum design thickness.

†Nominal specified Insituform® thickness (available in 1.5mm increments).

OVALITY

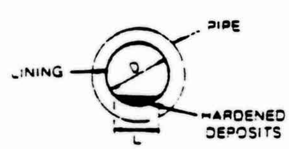


% OVALITY = $\frac{100 \times (\text{MAX DIA} - \text{MEAN DIA})}{\text{MEAN DIA}}$

OR

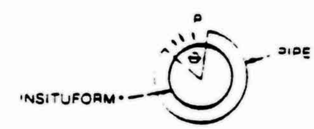
$\frac{100 \times (\text{MEAN DIA} - \text{MIN DIA})}{\text{MEAN DIA}}$

FLAT IN CIRCUMFERENCE



L/D × 100 = % FLAT TO DIA

MISSING SEGMENT IN CIRCUMFERENCE



θ = ANGLE OF MISSING SEGMENT SUBTENDED AT THE CENTER IN DEGREES

INSITUFORM® DESIGN FOR INTERNAL PRESSURE

The maximum internal pressure that can be applied to Insituform® depends mainly on the structural soundness of the existing pipe. Insituform® fits the inside diameter very closely and will deform under loading, allowing all stress to be transferred to the external pipe. Thus where the problem is leakage through pin holes or from the joints, the pressure rating of the original pipe may be maintained with only nominal Insituform® thickness.

Where there are only small holes in the external pipe, no ring tension will occur. Insituform® is assumed to be a circular flat plate fixed at the edge and subjected to transverse pressure only and the bending stresses will equal σ/N if

$$\frac{d}{D} = \frac{1.63}{\sqrt{SDR}}$$

Equation is tabulated:

d/D	.36	.30	.26	.23	.21	.19	.18	.16	.15	.13
SDR	20	30	40	50	60	70	80	100	120	150

where d is the diameter of hole and D the mean outside diameter of Insituform® (inside diameter of the pipe).

Buried pressure pipes should be designed to carry external hydrostatic loading in the event of the pipe being empty. This condition may be critical for large pipe with numerous holes or open joints carrying low internal pressure and non-bonded Insituform®; external pressure may regulate the thickness rather than the internal pressure rating. For the external loading conditions, refer to the appropriate charts in earlier sections.

$$^{*}p = \frac{5.33}{(SDR-1)^2} \left\{\frac{D}{d}\right\}^2 \frac{\sigma}{N}$$

for d/D equal to or less than table values above for the appropriate SDR of proposed Insituform® thickness.

*p = Allowable Internal Pressure σ Long Term Tensile Stress = 1,500 psi   N Safety Factor = 2

ALLOWABLE PRESSURE PSI vs. INSITUFORM® THICKNESS IN MILLIMETERS

Insituform® Thickness (mm) for $^{d}/D = 0.025$

PRESSURE	PIPE DIAMETER IN INCHES									
psi	6″	8″	10″	12″	15″	18″	21″	24″	30″	36″
0 - 50	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
51 - 150	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
151 - 300	3.0	3.0	3.0	3.0	3.0	4.5	4.5			
301 - 500	4.5	4.5	4.5	4.5	4.5	4.5	4.5			
501 - 1000	4.5	4.5	4.5	4.5						
1001 - 1500	4.5	4.5	CHECK PRESSURE RATING OF PIPE							

Insituform® Thickness (mm) for $^{d}/D = 0.10$

PRESSURE	PIPE DIAMETER IN INCHES									
psi	6″	8″	10″	12″	15″	18″	21″	24″	30″	36″
0 - 25	3.0	3.0	3.0	3.0	4.5	4.5	4.5	6.0	7.5	9.0
26 - 50	3.0	3.0	3.0	4.5	4.5	6.0	6.0	7.5	9.0	10.5
51 - 75	3.0	3.0	4.5	4.5	6.0	7.5	7.5	9.0	10.5	13.5
76 - 100	3.0	3.0	4.5	6.0	6.0	7.5	9.0	10.5	12.0	15.0
101 - 125	3.0	4.5	4.5	6.0	7.5	9.0	10.5	12.0	13.5	16.5
126 - 150	3.0	4.5	6.0	6.0	7.5	9.0	10.5	12.0	15.0	18.0

Insituform® Thickness (mm) for $^{d}/D = 0.20$

PRESSURE	PIPE DIAMETER IN INCHES									
psi	6″	8″	10″	12″	15″	18″	21″	24″	30″	36″
0 - 25	3.0	4.5	4.5	6.0	7.5	9.0	9.0	10.5	13.5	16.5
26 - 50	4.5	6.0	7.5	9.0	10.5	13.5	15.0	18.0	21.0	25.5
51 - 75	6.0	7.5	9.0	10.5	13.5	16.5	18.0	21.0	25.5	31.5
76 - 100	6.0	9.0	10.5	12.0	15.0	18.0	21.0	24.0	30.0	34.5
101 - 125	7.5	9.0	12.0	13.5	16.5	19.5	24.0	27.0	33.0	39.0
126 - 150	7.5	10.5	12.0	15.0	18.0	21.0	25.5	28.5	36.0	42.0

SECTION I — RECOMMENDED SPECIFICATIONS FOR INSITUFORM®

I-1 INTENT: It is the intent of this portion of this specification to provide for rehabilitating pipelines by the inversion of a resin impregnated flexible felt tube. The tube shall be saturated with a thermosetting resin and inverted into the existing pipeline utilizing an inversion standpipe and hydrostatic head. Curing shall be accomplished by circulating hot water to cure the resin into a hard impermeable Insituform® pipe. When cured, Insituform® should extend from end to end in a continuous tight fitting watertight pipe-within-a-pipe. Insituform® is a patented process installed by licensed installers.

I-2 REFERENCE SPECIFICATIONS AND MANUFACTURER'S STANDARDS: This specification references American Society for Testing and Materials (ASTM) standard specifications and Insituform of North America, Inc. (INA) manufacturer's standards which are made a part hereof by such reference and shall be the latest edition and revision thereof.

I-3 GENERAL CORROSION REQUIREMENTS: Insituform® shall incorporate thermosetting materials which will withstand the corrosive effects of the normal existing effluents, liquids or gases.

I-4 FLOW ANALYSIS (Industrial Areas Only): In industrial areas subject to mixed flows, the Owner shall obtain samples of the flow and have them analyzed. This analysis shall be supplied to the Installer for his information and use.

I-5 SIZING: The felt fiber tube shall be fabricated to a size that when installed will neatly fit the internal circumference of the conduit as specified by the Owner. Allowance for circumferential stretching during insertion shall be made as per INA manufacturer's standards.

I-6 LENGTH: The length shall be that deemed necessary by the Installer to effectively carry out the insertion from inlet to outlet points. The Installer shall verify the lengths in the field. Individual inversion runs can be made over one or more access points as determined in the field by the Installer and approved by the Owner.

I-7 INSITUFORM MATERIALS: The polyester felt tubing, including the polyurethane or poly-vinyl chloride covered felt and the thermosetting resin shall meet INA manufacturer's standards.

a) **General** — The Installer shall submit his proposal for the appropriate length and size designated on the proposal sheet. Insituform® thickness shall be specified for each line in the proposal form, unless otherwise stated.

b) The cured Insituform® shall conform to the minimum structural standards, as listed below.

I-8 PHYSICAL PROPERTIES

Cured Insituform®	Standard	Results
Tensile Stress	ASTM D-638	3,000 psi
Flexural Stress	ASTM D-790	3,000 psi
Modulus of Elasticity	ASTM D-790	300,000 psi

If so directed, the Installer shall furnish, prior to use of the materials, satisfactory written certification of his compliance with the INA manufacturer's standards for all materials and conformance with methods of the Insituform process.

I-9 DEVIATIONS: The deterioration of pipeline is an ongoing process. Should pre-Insituform® inspections reveal the pipes to be in substantially different conditions than those stated in the design considerations, then the Installer shall request a change in thickness supporting such request with design data in accordance with INA manufacturer's standard design policies. The deviation, if approved, shall be reflected by the appropriate addition or reduction in the unit cost for that size as shown in the optional portion of the proposal.

I-10 INSTALLATION PROCEDURES: The following installation procedures shall be adhered to unless otherwise approved by the Owner's representative.

a) **Safety** — The Installer shall carry out his operations in strict accordance with all OSHA and manufacturer's safety requirements. Particular attention is drawn to those safety requirements involving working with scaffolding and entering confined spaces.

b) **Cleaning of Pipelines** — Prior to Insituform® of any pipe so designated, it shall be the responsibility of the Installer to remove internal deposits from the pipeline (designate cleaning method here or refer to standard cleaning specification, if contained elsewhere in this document).

c) **Inspection of Pipelines** — Inspection of non-man-entry pipelines shall be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed circuit television. The interior of the pipeline shall be carefully inspected to determine the location and extent of any structural failures. The location of any conditions which may prevent proper installation of Insituform® into the pipelines shall be noted so that these conditions can be corrected. A video tape and suitable log shall be kept for later reference by the Owner/Engineer.

d) **Bypassing Flow** — The Installer when required shall provide for the transfer of flow around the section or sections of pipe designated for Insituform®. The bypass shall be made by diversion of the flow at an existing upstream or higher pressure access point and directing the flow around the section to be taken from service. Bypass lines and pumps, if necessary, shall be of adequate capacity and size to handle the flow. The proposed bypassing system shall be approved in advance by the Owner.

e) **Line Obstructions** — It shall be the responsibility of the Installer to clear the line of obstructions such as solids, dropped joints, protruding branch connections or broken pipe that will prevent the insertion of Insituform®. If inspection reveals an obstruction that cannot be removed by conventional cleaning equipment, then the Installer shall make a point to repair excavation, to uncover and remove or repair the obstruction. Such excavation shall be approved in writing by the Owner's representative prior to the commencement of the work and shall be considered as a separate pay item.

I-11 INSTALLATION OF INSITUFORM®

a) The Installer shall designate a location where the uncured resin in the original containers and the unimpregnated fiber felt tube will be vacuum impregnated prior to installation. The Installer shall allow the Owner to inspect the materials and 'wet out' procedure. A resin and catalyst system compatible with the requirement of this method shall be used. The quantities of the liquid thermosetting materials shall be per INA manufacturer's standards to provide the lining thickness specified.

b) The wet out fiber felt tube shall be inserted through an existing manhole or other approved access by means of an inversion process and the application of a hydrostatic head sufficient to fully extend it to the next designated access point. The impregnated fiber felt tube materials shall be inserted into the vertical inversion stand pipe with the impermeable plastic membrane side out. At the lower end of the inversion stand pipe, the tube shall be turned inside out and attached to the stand pipe so that a leakproof seal is created. The inversion head will be adjusted to be of sufficient height to cause the tube to invert to the next access point designated and to hold it tight to the pipe wall, to produce dimples at side connections and flared ends at the entrance and exit access points. The use of a lubricant is recommended by INA. The INA manufacturer's standards shall be closely followed during the elevated curing temperature so as not to over stress the felt fiber and cause damage or failure prior to cure. (In certain cases, the Contractor may elect to use a Top Inversion. In this method the impregnated tube is pre-inverted to a distance that corresponds to the minimum inversion head and instead of attaching to an elbow at the base of the inversion stand pipe, the tube is attached to a top ring.)

c) **Curing** — After inversion is completed the Installer shall supply a suitable heat source and water recirculation equipment. The equipment shall be capable of delivering hot water to the far end of the pipe section through a hose, which has been perforated per INA manufacturer's recommendations, to uniformly raise the water temperature in the line section above the temperature required to effect a cure of the resin. This temperature shall be determined by the resin. catalyst system employed.

The heat source shall be fitted with suitable monitors to gauge the temperature of the incoming and outgoing heat exchanger circulating water. Thermocouples shall be placed between the impregnated tube and the invert at the far access point to determine the temperature and time of exotherm. Water temperature in the pipeline during the cure period shall not be less than 150° F or more than 200° F as measured at the heat exchanger return line.

Initial cure shall be deemed to be completed when inspection of the exposed portions of Insituform* appear to be hard and sound and the thermocouples indicate that an exotherm has occurred. The cure period shall be of a duration recommended by the resin manufacturer, as modified for the Insituform* process, during which time the recirculation of the water and cycling of the heat exchanger to maintain the temperature continues.

d) **Cool Down** — The Installer shall cool the finished Insituform* to a temperature below 100° F before relieving the static head in the inversion stand pipe. Cool-down may be accomplished by the introduction of cool water into the inversion stand pipe to replace water being drained from the downstream end. Care shall be taken in the release of the static head such that a vacuum will not be developed that could damage the newly installed Insituform*.

e) **Finish** — The finished Insituform* shall be continuous over the entire length of the insertion run and be as free as commercially practicable from significant defects.

Any defects which will affect, in the foreseeable future, or warranty period, the integrity or strength of Insituform*, shall be repaired at the Installer's expense, in a manner mutually agreed by the Owner and the Installer.

I-12 SEALING THE ENDS: If due to broken or misaligned pipe at the access points, Insituform* fails to make a tight seal, the Installer shall apply a seal at that point. The seal shall be of a resin mixture compatible with Insituform*.

I-13 BRANCH OR SERVICE CONNECTIONS: After Insituform* has been cured, the Installer shall reconnect the existing active branch lines as designated by the Owner. This shall generally be done without excavation and in the case of non-man entry pipes, from the interior of the pipeline by means of a television camera and a cutting device that re-establishes them to not less than 90 percent capacity.

I-14 TESTING: The watertightness of Insituform* shall be gauged while curing and under a positive head. After the work is completed, the Installer will provide the Owner with a video tape showing both the before and after conditions including the restored connections.

I-15 CLEAN-UP: Upon completion of the installation work and testing, the Installer shall reinstate the project area affected by his operation.

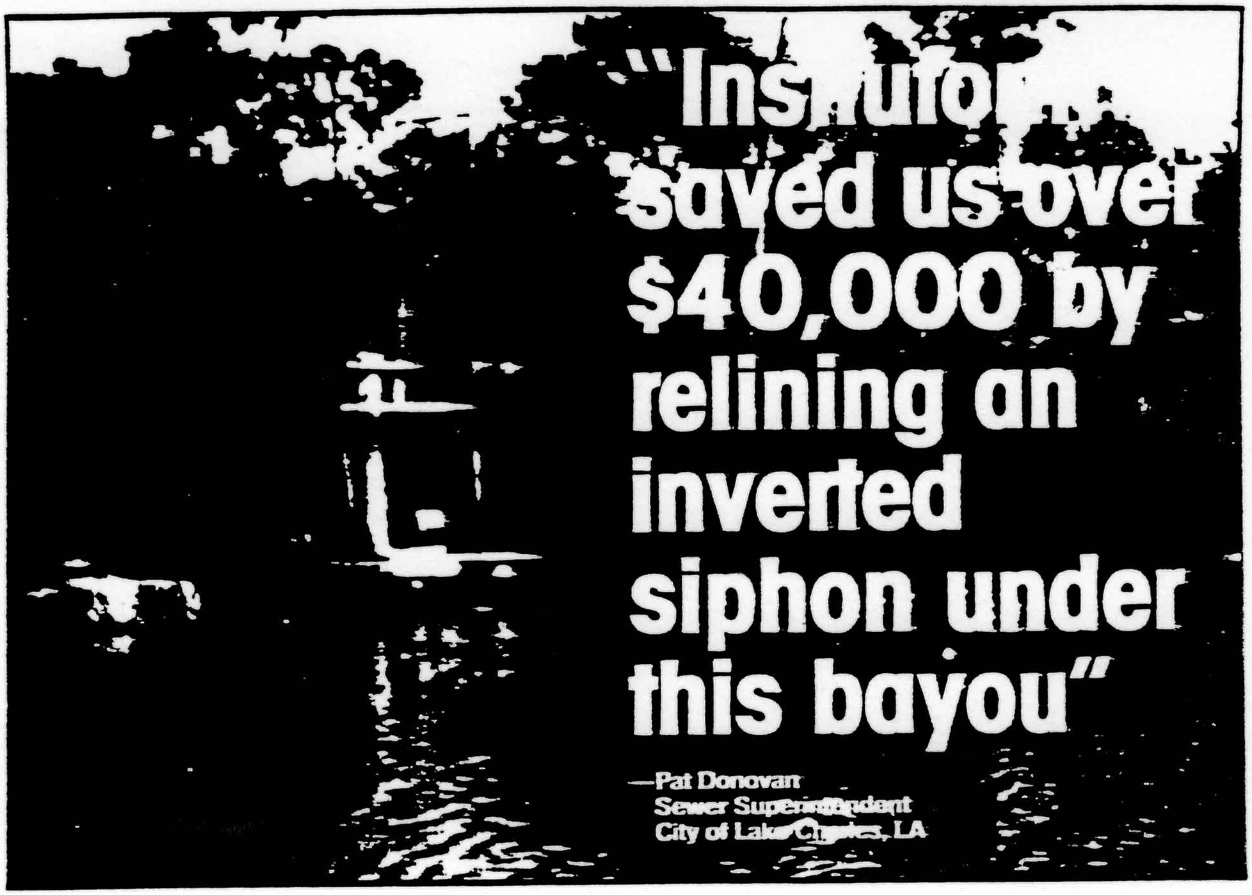
NOTE: A price and payment schedule should accompany these specifications to clarify methods of measurement and payment for Insituform* (including partial payment) and incidental items.

Before   After

INSITUFORM
OF NORTH AMERICA, INC.

3315 Democrat Road / P.O. Box 181071 / Memphis, TN 38118 / TWX 810-591-1252 / Ph. (901) 363-2105

945



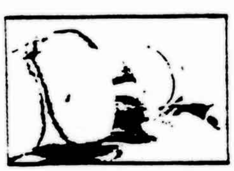
"Our engineering staff had recommended complete replacement because no known rehabilitation process could be effectively applied to an inverted siphon like this. No process, that is, until we discovered Insituform. By relining the Insituform way we saved over $40,000 compared to our projected replacement costs...and the work progressed without excavation in surrounding lawns."

How Insituform Works:

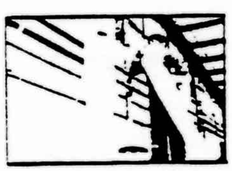
A resin-impregnated liner is fed into an inversion tube which has been erected on-site

The end of the liner is pulled through, turned inside-out

then clamped around the bottom of the angle inversion tube



The weight of a column of water added from above inverts the liner and pushes it into the pipe being rehabilitated.



As more water is added, additional liner is fed into the tube

After the entire liner is in place, the water is heated and recirculated to cure the liner and literally form a new pipe within the old.

Insituform is a better method of pipeline rehabilitation. This remarkable process uses a flexible polyester fiber felt liner that is installed through existing manholes, so no excavation is needed. The liner conforms to the interior of the pipe, filling cracks, bridging gaps at separated joints, negotiating bends, and even pushing groundwater aside. Upon curing, Insituform forms a tough durable new pipe within the old. And because joints are eliminated, the new Insituform pipe is often smoother than the original, thus increasing the flow and reducing maintenance needs.

The Insituform process can be used in pipes from 4" to 108" in diameter, to transport almost any type of liquid. Test results and case histories are available. Call or write for further information about applications you may have in mind.

INSITUFORM
OF NORTH AMERICA, INC.

3315 Democrat Road/P.O. Box 181071
Memphis, TN 38118/Ph. (901) 363-2105

Equally as useful in industrial pipes!

Public Works

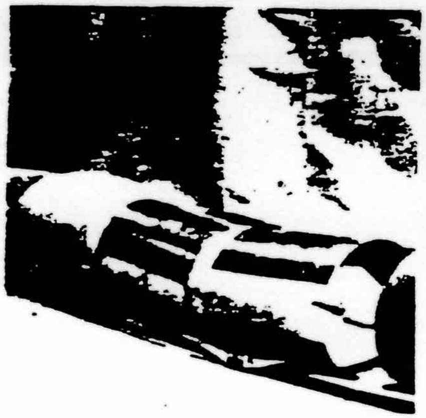
New Sewers from Old: The Anatomy of an Innovation Transfer

Public works directors are generally conservative types. They want to make darn sure that a product or process for which they are spending taxpayer money really performs the way it is supposed to. Their reputation is, after all, on the line and who can blame them for being prudent? Yet prudence is rarely found on the leading edge of innovation and we think it's news when a public works director refers to a British sewer relining process, only recently introduced in this country, with great praise. Richard O. Thomasson of the Washington Suburban Sanitary Commission (WSSC) says that "Instituform can certainly be considered the ultimate best answer for some of those restoration projects which all sewer agencies encounter and which, before Instituform, seemed to defy feasible solution." Quite an endorsement.

The process was developed by a British engineer, Eric Wood, in 1971. It came to the States in 1977 and is now applied in a variety of locations from coast to coast, including R&D projects sponsored by EPA. Under the unique process, a resin impregnated felt lining is inverted and fed into the sewer or water line to be repaired. This material is then "cured" in place to form a highly resilient and corrosion-resistant lining. After the process has been completed, the lining becomes a hard, impermeable pipe-within-a-pipe. By varying the particular resins used, the Insituform process is applicable to almost any industrial or municipal requirements.

Insituform is inserted through manholes by means of an inversion tube with its end turned inside out and attached by a ring to the end of the tube. The lining is then blown under water pressure into the damaged or leaking sewer line. Cold water pumped through the inversion tube forces the liner firmly against the inner wall to which the resin side adheres. When the lining is fully extended, the cold water is recirculated through a boiler and discharged into the pipe by a layflat tube at 160 degrees. When the cure cycle is complete after several hours, the tube is withdrawn, the water pumped out, the ends of the liner cut off and the lateral openings covered by the initial application of Insituform restored quickly and cleanly from the inside using a high resolution television camera followed by the "Insitucutter," both pulled along by an armored power supply cable.

Advantages in using the Insituform process include:



The Insituform process illustrated above creates a new "pipe within a pipe".

- Quicker and more economical installation;
- Adaptability to both extreme hot or cold climates;
- Minimal inconvenience to citizens and businesses;
- Unconstricted or improved flow capabilities of pipelines;
- Adaptability to almost any shape pipeline;
- Suitability for pipelines with numerous lateral connections;
- Resistance to chemicals—various resins can be used.

One of the first major U.S. relining projects was undertaken by Insituform East, Inc., a licensee of Insituform of North America, for the Washington Suburban Sanitary Commission (WSSC). An exclusive country club that sat on top of part of the rehabilitation project had adamantly resisted rehabilitation work on an interceptor sewer that traversed club property for fear of excavation on the manicured golf course. The Commission implemented the Insituform technique to solve the logistical problem. With the assurance that the Insituform process would not disturb club property, work got underway.

More than three thousand linear feet of line were renovated at the country club in a period of three weeks. Under conventional replacement methods, this same project would have taken a year to complete. Using the Insituform method, most of the work was done at night with golfers scarcely missing a stroke. Total cost of the country club project was $336,847, or an average unit cost of $102.94 per linear foot. It was estimated that by using the Insituform method, almost $500,000 was saved.

So far, WSSC has restored a total of 59,619 feet of sewer using the Insituform method, with sewers ranging in size from six inches to 24 inches.

A comparison survey between total replacement, slip lining and Insituform on

Use of existing accesses minimalizes excavation and environmental disruption.

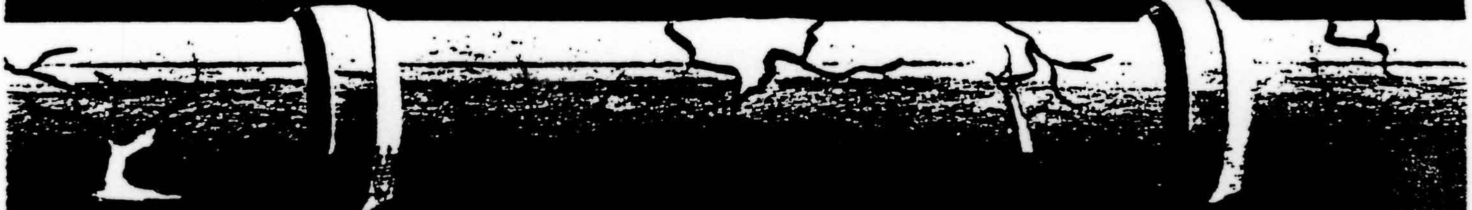
several comparable projects, shows that the Insituform process costs an averge of $50 per linear foot of pipeline. Costs for total replacement averages $150 per linear foot. Slip lining, based on the same comparison techniques, costs $85 per linear foot. The savings using the Insituform process vary from $35 to $100 per linear foot, depending upon field conditions encountered on site.

If you are worried how long the repair job will last, the current estimate is up to fifty years so you can hand the problem to your Council in 2031. (We have contact information for the responsible public works officials and the regional licensees of the British process.)

NOW THERE'S A BETTER METHOD OF PIPELINE REHABILITATION

INSITUFORM T.M.

OF NORTH AMERICA, INC.



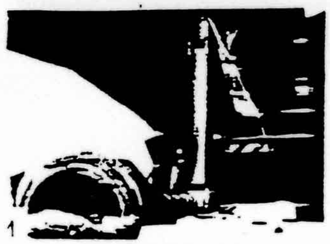
HOW INSITUFORM® WORKS:

The Insituform® process is basically very simple. A liner impregnated with a liquid resin is fed into an inversion tube which has been erected on-site. The liner has an impermeable coating on the outside which eases handling and provides a water barrier for the inversion process. (see fig. 1)

The end of the liner is pulled through, turned inside-out (see Fig. 2)

... then clamped around the bottom of an angle inversion tube (see Fig. 3)

Water from nearby hydrants fills the inversion tube, then the weight of the column of water pushes the felt liner inside-out and into the pipe being rehabilitated (see Fig. 4)



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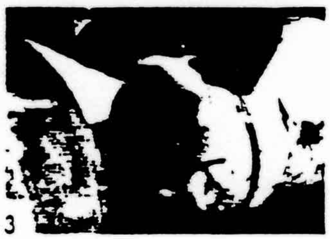

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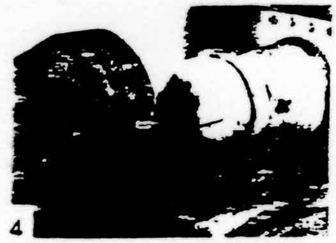
As more water is added to maintain the weight of the column and additional liner is fed into the tube the liner snakes its way forward through the pipe (see Fig. 5)

The weight of the water presses the coated felt at the nose inverts it and then presses the resin impregnated side hard against the insides of the damaged pipe, leaving the smooth coated side as the new interior surface of the rehabilitated pipe. After the liner reaches the next manhole or other access point the water is heated to cure the resin forming an impermeable new pipe within the old. The ends are cut off, the head of water is released and the lining operation is complete (see Fig. 6)



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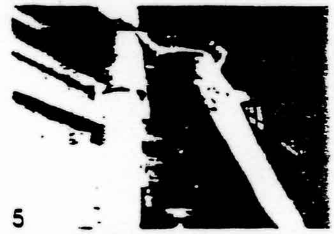

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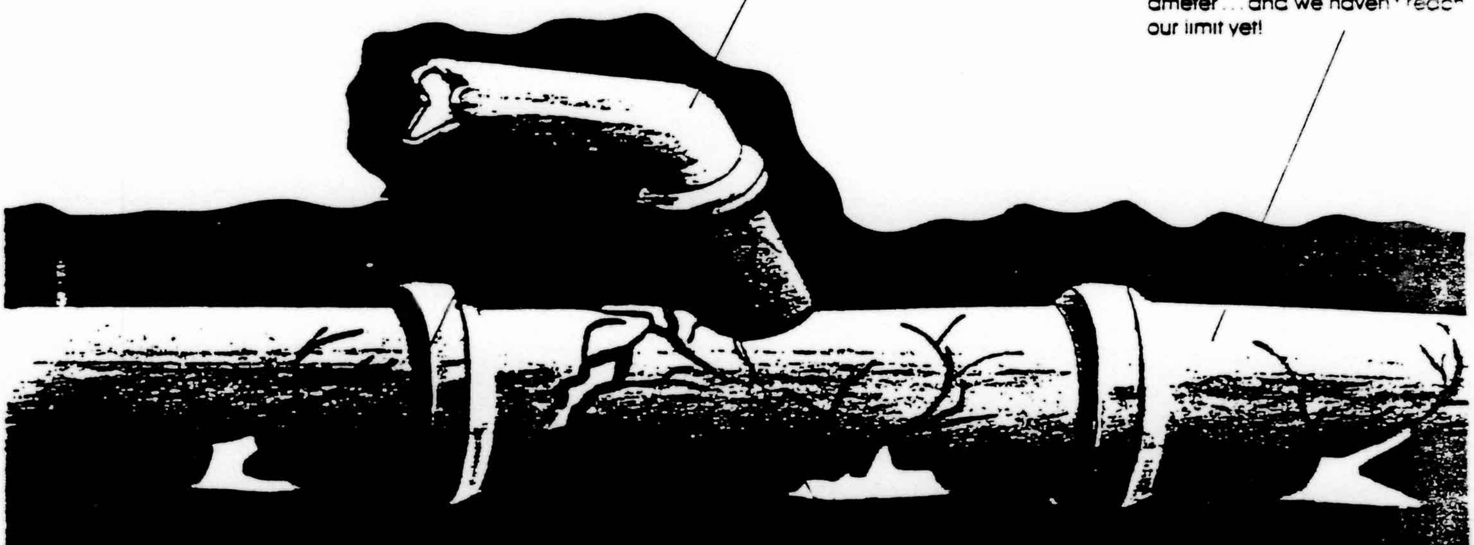


INSITUFORM™

LITERALLY CREATES A BETTER PIPE WITHIN THE OLD

Insituform® offers a quicker and often more economical approach to sewer and pipeline rehabilitation. The process utilizes a polyester felt liner which is tailored to the diameter and length of the pipe to be repaired. The liner, impregnated with a liquid thermosetting resin, is installed by use of an inversion tube and water pressure, which turns the liner inside out and forces it into the pipe, snugly against the damaged pipeline's interior surfaces. When the liner is fully extended the water is heated and recirculated to harden the resin, thus forming an impermeable corrosion-resistant new pipe within the old.

No other rehabilitation method can match the overall ease of installation and the versatility of the Insituform® process. In fact, in many badly deteriorated segments of pipe, Insituform® is the *only* feasible alternative to total replacement.

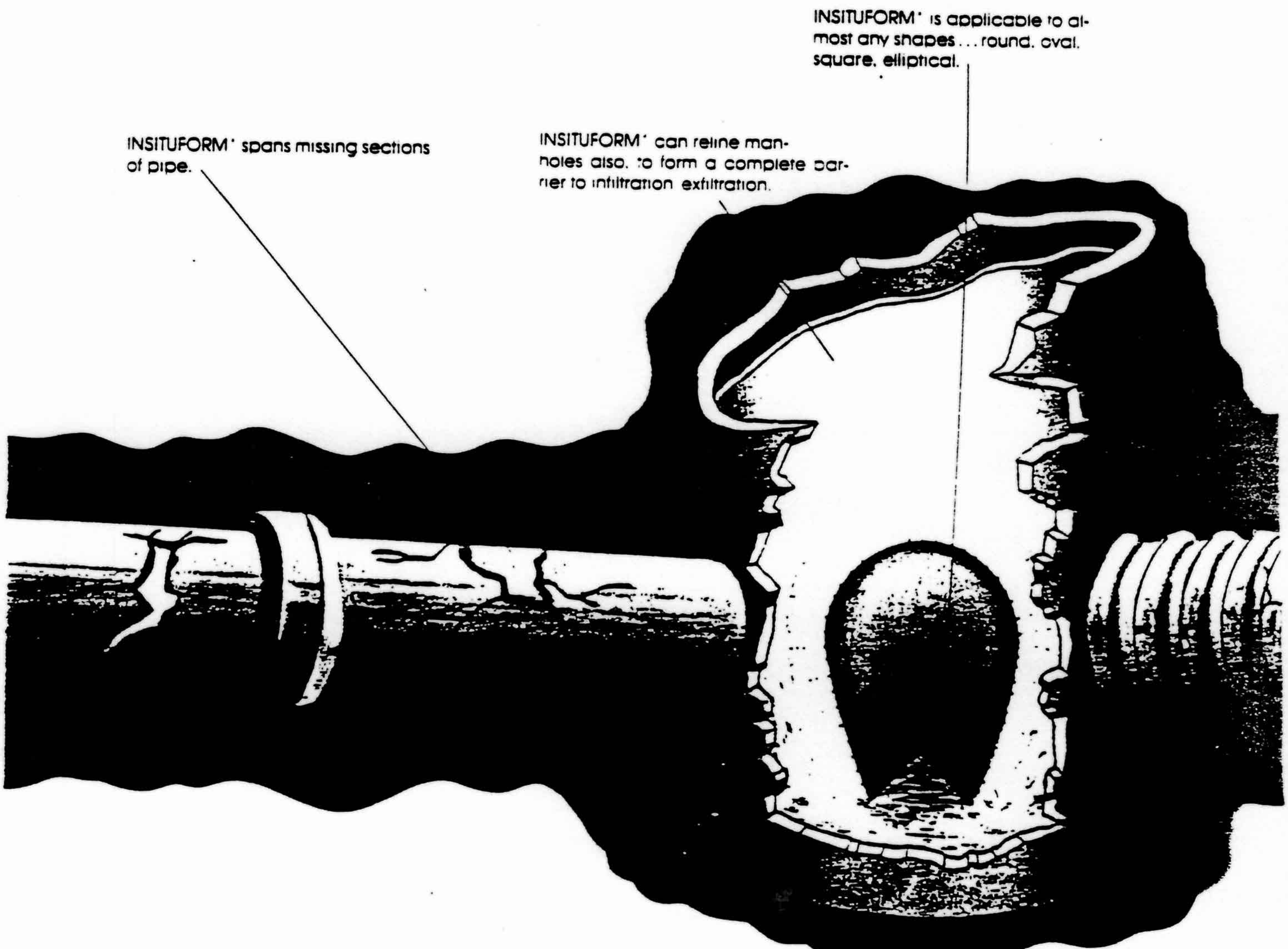
Insituform® is quick and simple. Economical. Effective. And lasting.

INSITUFORM™

BRIDGES GAPS, FILLS HOLES AND CRACKS, TURNS ANGLES.

Upon insertion, Insituform® is pliable and the resin is in a viscuous liquid state, allowing Insituform® to bridge gaps, fill cracks, push ground water aside and even turn wide angles. And because the liner itself is relatively thin ([illegible] to [illegible], depending upon application), it molds itself tightly against the inner walls of the pipe to form a smooth surface that often improves the overall flow capacity. The Insituform® process can be used in almost any shape pipe—circular, oval, square, egg-shaped—from 4" to [illegible] in diameter.

Any lateral connections covered over during the lining process are easily restored using a remote controlled Insitucutter which works from within the pipeline without external excavations—an advantage which makes Insituform® especially well suited for pipelines with numerous connections and limited access.



INSITUFORM T.M.

HAS PROVEN ITSELF IN BOTH MUNICIPAL AND INDUSTRIAL INSTALLATIONS.

The Insituform® process is a state-of-the-art technique now serving the pipeline rehabilitation needs of customers in 26 nations around the globe. Insituform® seals, strengthens and preserves municipal and industrial pipelines by building a smooth wall, corrosion resistant pipe-within-a-pipe.

Insituform® successfully halts infiltration/exfiltration of groundwater in deteriorated pipe systems. Stops infiltration of fine sand which undermines pipes and causes surface collapse. Prevents root penetration and debris formation by eliminating places for debris to accumulate. And thus saves thousands of dollars in sewer pipeline rehabilitation, operation and maintenance costs.

Insituform.® It's the practical alternative to costly pipe replacement.

INSITUFORM T.M.

MINIMIZES INCONVENIENCE TO CITIZENS AND BUSINESSES.

In the Insituform® process, the lining enters the pipeline through manholes or existing accesses. Thus, Insituform® requires minimal excavation as compared with other methods, and eliminates much inconvenience normally associated with pipeline repair. No long entrance trenches. No destroyed lawns or streets. And—because work often occurs during non-peak evening hours, traffic flows, factory work, commerce and the public are hardly inconvenienced. Most work is performed in a fraction of the time of other methods, so overall environmental impact is held to a minimum.

INSITUFORM T.M.

LIVES UP TO ITS PROMISES.

"Insituform® is truly innovative and a much-needed sewer restoration technique. Insituform® can certainly be considered the ultimate, best answer for some of those restoration projects which all sewer agencies encounter and, before Insituform®, seemed to defy feasible solution."

Richard O. Thomasson
Washington Suburban Sanitary Commission
Washington, D.C.

"Our firm has investigated a number of Insituform® installations across the country. Generally, in every application studied the lining was implemented to eliminate either infiltration or exfiltration from sewer stretches. Without exception the parties interviewed agreed that the product was very effective in the performance of this designated task, and all would consider specifying the technique again."

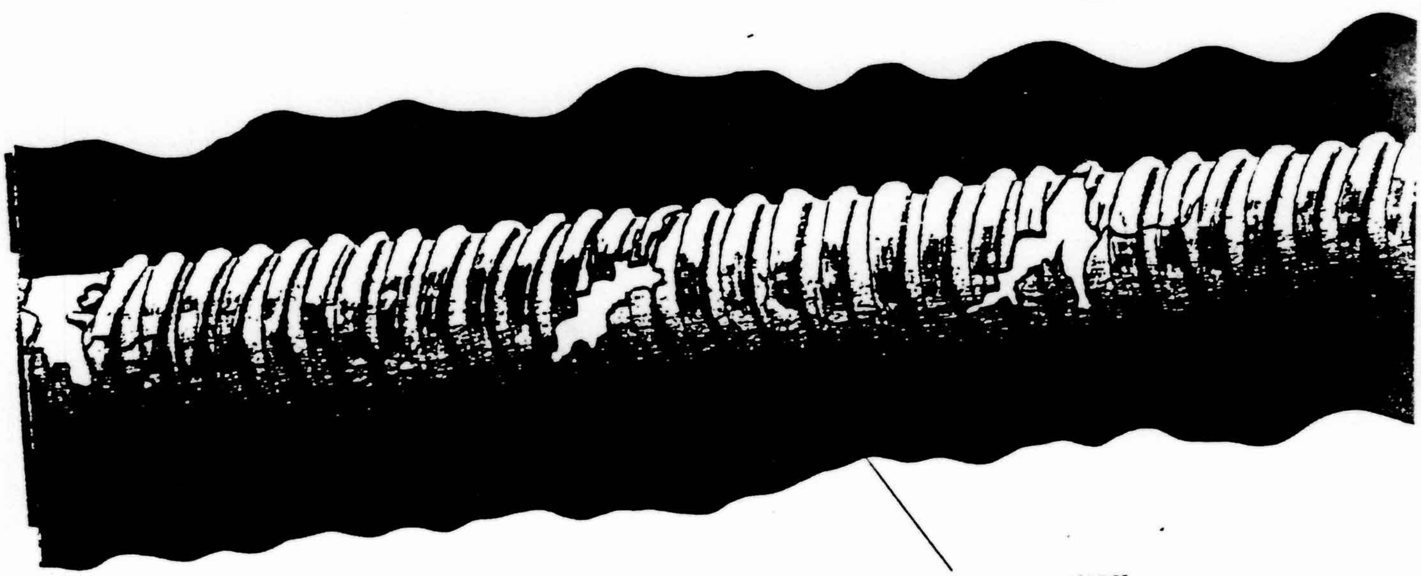
F.T. Driver, Consulting Engineer
Driver, Olson & DeGraff
Rockford, Illinois

"In region III we have proven that Insituform® is the only way to go. Not only is it cost effective, but it saves in other ways as well. In our pursuit of better water quality, I believe that, if all cities used the Insituform® way of handling their eroding sewers we would be successful, and also save taxpayers billions of dollars."

M.G. "Mike" McGauhey
Administrator Water Pollution Control Dept.
City of Hagerstown, MD

"Insituform® is the greatest innovation that has come along in the restoration of sewer lines."

Ed Brennan
Public Works Director
South Daytona, Florida



INSITUFORM® conforms to the interior shape of the pipe being rehabilitated, whether corrugated metal, clay pipe, brick or other materials.

APPENDIX B

ISCO REFRIGERATOR SAMPLER

refrigerated samplers

These three refrigerated samplers preserve biological specimens during and after collection. They are light and compact, and can be easily installed in any place affording reasonable protection from the elements. They are suitable for use whenever permanent installation is required. The controller/pump assemblies on two of these samplers are identical to, and interchangeable with, those of the Models 1680 and 1580 portable samplers. Information relating to sample collection will be found in the descriptions of these portable samplers. A refrigerated version of the Model 2100 is not available.

The Model 1580R refrigerated composite sampler can be supplied with a 3 or 5 gallon polyethylene container or a 2½ gallon glass container. These containers have a large mouth and are easily cleaned. When the container is filled to any predetermined level, a weight activated switch stops the sampling process and a red indicator light alerts the operator.

The Model 1680R uses the sequential controller and a slide-in 28 bottle rack. Ample room is provided for 32 additional loose bottles.

A third refrigerated sampler, the Model 1682R, takes eight samples of up to two liters each in either glass or polyethylene bottles. The standard controller includes a multiplexer so that eight identical composite samples may be taken with a different preservative in each bottle if desired. For other purposes, eight large sequential samples may be collected, with each sample being a composite of up to eight smaller increments. The Model 1682R has no portable equivalent. Controller specifications are basically the same as the Model 1680, but a Model 1680 controller cannot be converted to the eight bottle version.

Rigid foamed-in-place insulation stiffens the refrigerated compartment, and will not support bacterial growth or retain odors. Both the controller and sample compartment may be individually padlocked. The door utilizes a magnetic gasket for better sealing. Sample temperature can be selected from 32° to 46°F (0° to 8°C) with a calibrated control. A forced air condensing coil and front ventilation allow positioning the unit against a wall or in a corner without leaving clearance on the back or sides. Wraparound construction of the oversized evaporator coil provides quick and efficient cooling of the sample compartment. Defrosting is not required under normal operating conditions.

If it is desired to convert a presently owned portable sampler to a refrigerated unit, or to have both portable and refrigerated options on the same sampler, a refrigerator unit only may be ordered. These units are identical to the complete refrigerated samplers except the controllers (programmer and pump assemblies) are excluded. Changing a controller from the portable to the refrigerated version takes only a few minutes. Each refrigerated unit includes the sample container(s), suction line, and all standard accessories.

Height of the cabinet is 42½", width is 24¼", and depth is 25½". Net weight is 116 lb. Available for AC line power only.

A COMPLETE REFRIGERATED 1680R or 1682R SAMPLER CONSISTS OF:

1. **THE BASIC UNIT**
2. **SUCTION LINE AND STRAINER**

YOU MUST SPECIFY YOUR CHOICE OF THE ABOVE FROM 1 AND 2 BELOW:

1. THE BASIC UNIT

A. MODEL 1680R for 117VAC, 60HZ OPERATION

Catalog Number	Pump	Bottles	Multiplexer?
68-1730-077	Standard	Polyethylene	Yes
68-1730-078	Standard	Polyethylene	No
68-1730-079	Standard	Glass	Yes
68-1730-080	Standard	Glass	No
68-1730-081	Superspeed	Polyethylene	Yes
68-1730-082	Superspeed	Polyethylene	No
68-1730-083	Superspeed	Glass	Yes
68-1730-084	Superspeed	Glass	No

B. MODEL 1680R FOR 234VAC, 50HZ OPERATION

68-1730-085	Standard	Polyethylene	Yes
68-1730-086	Standard	Polyethylene	No
68-1730-087	Standard	Glass	Yes
68-1730-088	Standard	Glass	No
68-1730-089	Superspeed	Polyethylene	Yes
68-1730-090	Superspeed	Polyethylene	No
68-1730-091	Superspeed	Glass	Yes
68-1730-092	Superspeed	Glass	No

C. MODEL 1682R FOR 117VAC, 60HZ OPERATION

68-1730-093	Standard	Polyethylene	Yes
68-1730-094	Standard	Glass	Yes
68-1730-095	Superspeed	Polyethylene	Yes
68-1730-096	Superspeed	Glass	Yes

D. MODEL 1682R FOR 234VAC, 50HZ OPERATION

68-1730-097	Standard	Polyethylene	Yes
68-1730-098	Standard	Glass	Yes
68-1730-099	Superspeed	Polyethylene	Yes
68-1730-100	Superspeed	Glass	Yes

2. SUCTION LINES AND STRAINERS

1/4" I.D. x 22' Vinyl suction line with polypropylene bodied inlet strainer, for use with standard speed pump samplers only 60-1394-054

3/8" I.D. x 20' vinyl suction line with polypropylene bodied inlet strainer, for use with standard and super speed pump samplers 60-1684-035

ACCESSORIES FOR 1680R and 1682R

Extra 28 bottle rack for Model 1680R, with polyethylene bottles 60-1734-005

Extra 28 bottle rack for Model 1680R, with glass bottles 68-1730-101

For extra bottles only for the Model 1680R, see Page 6

Extra 8 bottle rack for Model 1682R, with polyethylene bottles 60-1734-018

Extra 8 bottle rack for Model 1682R, with glass bottles 68-1730-102

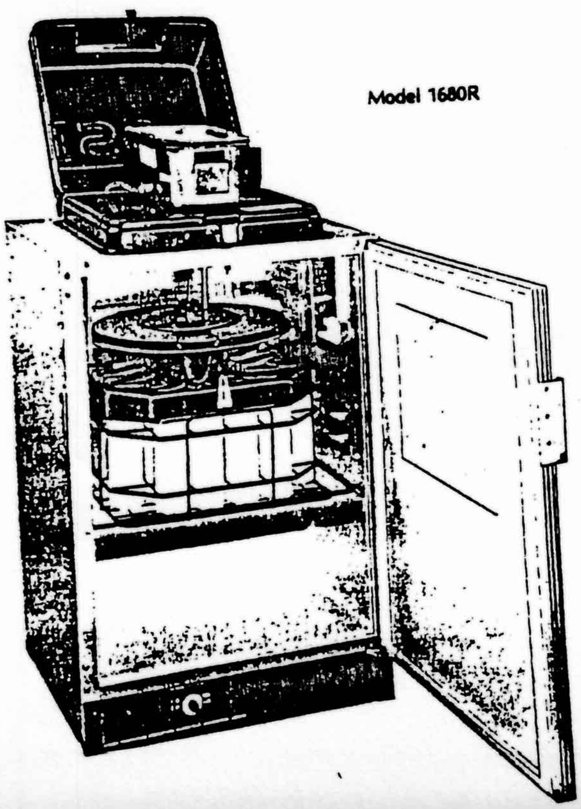
Polyethylene bottles only for Model 1682R, set of 8 with caps 68-1730-037

Glass bottles only for Model 1682R, set of 8 with caps 68-1730-038

Teflon lid liners for 2-liter glass bottles 60-1483-094

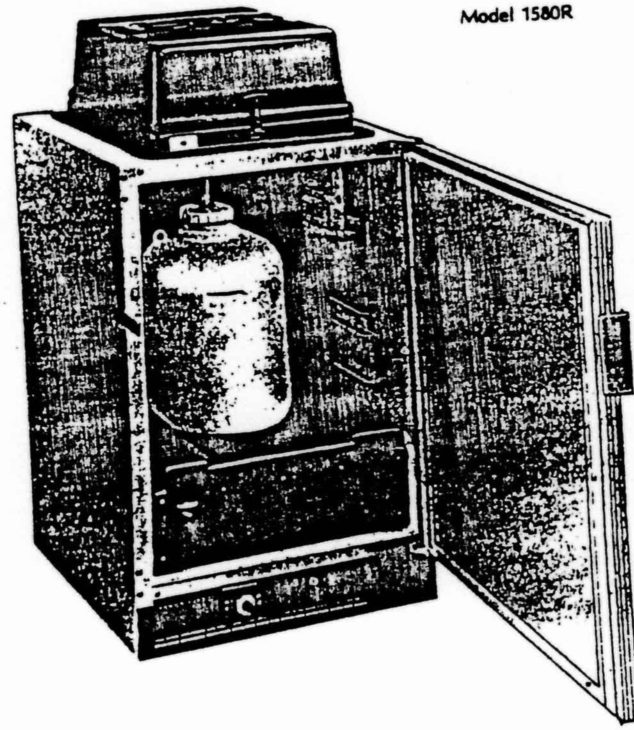
Extra silicone rubber pump tube for either Model 1680R, or 1682R, 17" 60-1684-016

Extra silicone rubber pump tubing, bulk, 15' long 68-1680-061



Model 1680R

Model 1580R



A COMPLETE MODEL 1580R REFRIGERATED SAMPLER CONSISTS OF

1. THE BASIC UNIT
2. A SAMPLE CONTAINER
3. A SUCTION LINE WITH STRAINER

YOU MUST SPECIFY YOUR CHOICE OF THE ABOVE FROM 1, 2, AND 3 BELOW:

1. THE BASIC UNIT

Catalog Number	Pump	Power Source
60-1624-023	Standard	117VAC, 60Hz
60-1624-024	Superspeed	117VAC, 60Hz
68-1620-009	Standard	234VAC, 50Hz
68-1620-010	Superspeed	234VAC, 50Hz

2. SAMPLE CONTAINERS

3-Gallon polyethylene container with lid and polypropylene lid liner.................................. 299-0013-02

5-Gallon polyethylene container with lid and polypropylene lid liner.................................. 68-1620-014

2½ Gallon glass container with lid and polypropylene lid liner.................................. 68-1620-013

Teflon lid liner for 2½ Gallon bottle cap 60-1483-092

3. SUCTION LINES AND STRAINERS

1/4" I.D. x 22' vinyl suction line with weighted polypropylene bodied strainer 60-1394-054

3/8" I.D. x 20' vinyl suction line with weighted polypropylene bodied strainer 60-1684-035

3/8" I.D. x 10' Teflon® suction line, Neoprene® rubber protective coating, without strainer 60-1683-146

Same, except 20' length 60-1683-144

Weighted strainer only, 3/8", all stainless steel 60-1684-110

Teflon® suction line flaring tool, to allow insertion of above strainer 60-2103-093

PUMP TUBING

Extra silicone rubber tube, 32" long 60-1624-015

Extra silicone rubber pump tubing, bulk, 15' long 68-1680-061

REFRIGERATORS ONLY, COMPLETE EXCEPT FOR CONTROLLERS

Model 1620, for use with Model 1580 Controller, 117VAC, 60Hz 68-1620-011

Same, except for 234VAC, 50Hz 68-1620-012

Model 1730, for use with Model 1680 Controller, 117VAC, 60Hz 68-1730-039

Same, except for 234VAC, 50Hz 68-1730-040

ISCO

Environm[illegible]
P.O. Box [illegible]
Lincoln, NE [illegible]
Phone (800) 228-4373
Telex 43-8026

QUOTATION

QUOTATION NO. 1747[illegible]

To: Mr. Gene Dworzanski
Hooker Chemical Co.
PO Box 344
Niagara Falls, NY 14302

Orders Are To Be Addressed To:

ISCO, Environmental Division
Burgh Schoenenberger Associates
10108 Starr Road
Wyoming, NY 14591

Date: August 27, 1984

Your Inquiry: Flow Monitoring

This quotation is made on the express condition that the terms stated below and on the reverse side are the exclusive terms and conditions of this transaction.

QUANTITY	CATALOG NUMBER	ITEM AND PRICE		
1	60-1624-023	Isco Model 1580R refrigerated sampler Standard (WITH SUPERSPEED PUMP)	$2120.00	
1	68-1620-017	3 gallon polyethylene container with lid and polypropylene lid liner	46.00	
1	60-1784-0[illegible]	Interface device Type C for 117VAC operation. Converts current signal proportional to flow (4-20ma) to pulse outputs occurring at settable flow intervals	375.00	
1	68-1394-077	Connector, with 22' cable terminating in two wires, for use with non-Isco flow meters having an isolated contact closure proportional to flow	32.00	
		TOTAL		$2573.00

If an order for a dollar volume of between $10,000 and $20,000 is ordered, there will be a discount of 5.5% available on the order.

6 NEEDED
.001 · RIVER
.003 · 8 AREA
.004
.005

By [signature]
ISCO Sales Representative

Prices are F.O.B. Factory
Estimated shipment 3-4 weeks after receipt of order.
This quotation expires in 30 days.
Prices include packing for domestic shipment. Special crating extra unless noted.

APPENDIX C

MAGNETIC FLOWMETER

Technical Information

2800 SERIES MAGNETIC FLOWTUBES

Proven dependability and versatility in use make Foxboro 2800 Series Flowtubes your first choice for measuring clean, as well as extremely difficult-to-handle, liquids.

INTRODUCTION

A magnetic flowtube is the primary in-line device in a magnetic flowmeter. It is used to measure the flow rate of electrically conductive liquids. The flowtube produces a dc or ac millivoltage. This low-level voltage is directly proportional to velocity and translatable to volumetric flow rate. It is converted into a standard transmission signal by a Foxboro magnetic flow transmitter.

Most industrial and municipal water/waste liquids can be measured by magnetic flowmeters. Acids and bases are common applications. Water and other clean liquids which can be measured by other devices, such as orifice meters, can also be measured with magnetic flowtubes to take advantage of their many desirable features. Liquids with suspended solids and certain waste flows, often impossible to meter otherwise, are dependably measured with magnetic flowtubes. The primary requirement is that the liquid have at least some minimum ability to conduct electricity.

CONTENTS . . .

	1
Introduction	2
Principle of Operation	2
Flowtube Construction	8
Industrial Applications	10
Product Safety	10
Optional Features	11
Summary	

FOXBORO®

®Registered Trademark

PRINCIPLE OF OPERATION

The operation of a magnetic flowtube is based on Faraday's law of electromagnetic induction. Voltage (V_o) is induced in a conductor moving through a magnetic field.

The voltage is proportional to the intensity (T) of the magnetic field, multiplied by the length (D_e) and the velocity (v) of the conductor.

$$V_o = (T)(D_e)(v)$$

In a magnetic flowtube, process liquid is the conductor and the distance between electrodes (flowtube diameter) is the conductor length. Figure 1 illustrates the basic principle of operation. A magnetic field is created by coils outside the tube, and the process liquid flows through the field inside the tube. A flowtube must be built so that the generated voltage is not dissipated through the walls of the tube.

Figure 2 shows the key components of an actual magnetic flowtube. Two metal electrodes, mounted in the flowtube wall, sense the voltage induced by the flow of the process liquid. This voltage is directly proportional to the average velocity of the liquid passing through the flowtube. The flowtube coils are energized by an ac or pulsed dc power source depending upon its calibration. The magnetic field and resultant induced voltage have the same characteristics as the energizing current. The millivolt output signal is protected from interference by screens (shields) and amplified by a transmitter into a standard transmission signal.

The metering tube is basically a conduit for the process liquid. If the tube is metal, it must have a lining (which serves as an electrical insulator) on its inside wall. A pair of electrodes, extending through the wall of the tube, are essentially flush with the inside surface of the tube. The tube end connections are usually flanged for mounting in a pipeline. Flared ends for quick-disconnect clamps (sanitary flowtubes) and plain ends for Dresser couplings (largest sizes) are also used.

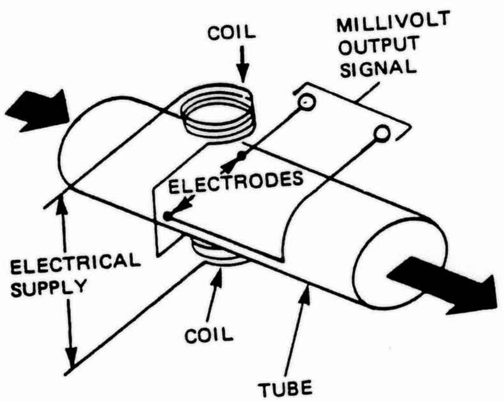


Figure 1. Operational Schematic Drawing

Mounted outside the tube are a pair of coils which create the electromagnetic field in the tube. A laminated transformer steel core mounts around the coils. This core completes the magnetic circuit and magnetically shields the measuring zone. Screened (shielded) leads connect the electrodes to terminals where the transmitter cable is attached. Except for the ends of the metering tube, the entire flowtube is enclosed by a sealed housing.

FLOWTUBE CONSTRUCTION

Metering Tubes

Basic Materials Because the magnetic field is created outside the tube, non-magnetic tube materials must be used. AISI 300 Series stainless steel—the standard for all Foxboro lined-metal flowtubes—does not limit or distort the magnetic field. It is available in the standard pipe sizes required and is a corrosion-resistant material. The four choices of lining for stainlees steel tubes are listed in Tables 1 and 2. A tabulation of tube materials and electrode metals is given in TI 27-71f. Data is included on chemical compatibility with various process liquids suitable for measurement by magnetic flowtubes.

Unlined Resin Tubes Also listed in Tables 1 and 2 are unlined glass fiber-reinforced resin flowtubes. Smaller diameter units (200 mm [8 in] and smaller) have epoxy resin as the glass bonding agent. Polyester resin is used in the larger tubes. In all sizes, the inner wall is a smooth glass-free resin surface. Measurement voltage cannot dissipate into the pipeline with these nonconductive/nonpermeable tubes. This eliminates the need for an insulating liner. Tubes of this construction are nonmagnetic. Reinforced resin flowtubes are lower in price than corresponding sizes of lined metal units, yet are suitable for a wide variety of applications.

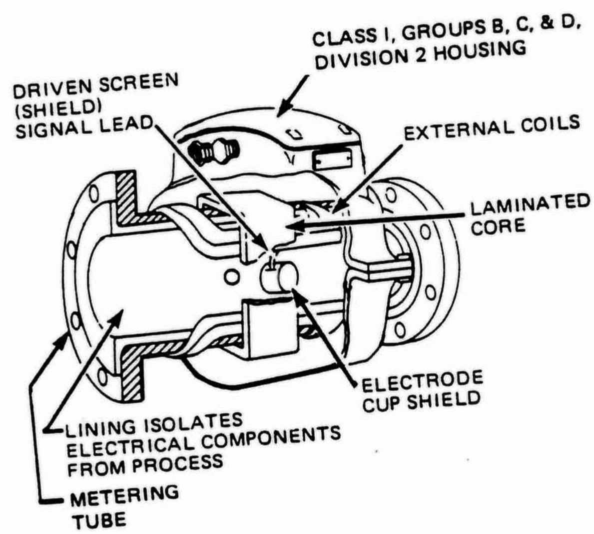


Figure 2. Cut-away View

ptfe Lined For ptfe-lined stainless steel tubes, the recommended maximum steady process temperature is 175°C (350°F). Because of this high temperature rating, and because of its inertness to a wide range of acids and bases, ptfe is the most widely used flowtube lining material. Preformed "tubes" of ptfe are mechanically fitted into the stainless steel tube, and the ptfe ends are flared out over the flowtube end connections to effectively isolate process liquid from the metallic tube.

pfa Lined Similar to the ptfe-lined flowtube, the pfa-lined stainless steel flowtube has a recommended maximum steady process temperature of 175°C (350°F) and is chemically inert to a wide range of acids and bases. Because of its moldability, pfa is used in the smallest sized flowtubes, i.e., 2.5 and 6 mm (1/10 and 1/4 in) sizes. The pfa is injection molded into the stainless steel tube and is flared over the end connections to form a gasket and isolate the process liquid from the metallic tube.

Polyurethane Lined In some applications, a ptfe flowtube lining does not have adequate abrasion resistance. Where extreme resistance to wear or erosion is required, due to solid particles in the process stream, a polyurethane lining is often the best choice. In 2800 series Flowtubes, the polyurethane lining extends over the flange raised face. Polyurethane is much more resilient and abrasion resistant, but cannot be used at high temperatures or with strong acids or bases.

Neoprene Lined Neoprene is a flowtube lining material which combines some of the resistance to chemical attack of ptfe with a good degree of abrasion resistance. In 2800 Series Flowtube construction, a Neoprene lining also extends out over the flange raised face. Neoprene-lined flowtubes, with a slightly higher temperature rating than polyurethane-lined, are general-purpose units.

Sanitary Lined A ptfe-lined flowtube, with quick-disconnect sanitary end connections, is used in consumable product processes. These sanitary flowtubes are ideally suited for use with dairy products, beer, soft drinks, coffee, molasses, and corn syrup. Processed products, such as catsup and other viscous, sticky, or otherwise difficult-to-measure liquids, are also easily measured. The sanitary flowtube, shown in Figure 3, is of crevice-free construction which permits CIP (clean-in-place) operation. It meets 3-A standards, and U.S. Food and Drug Administration regulations for food contact service.

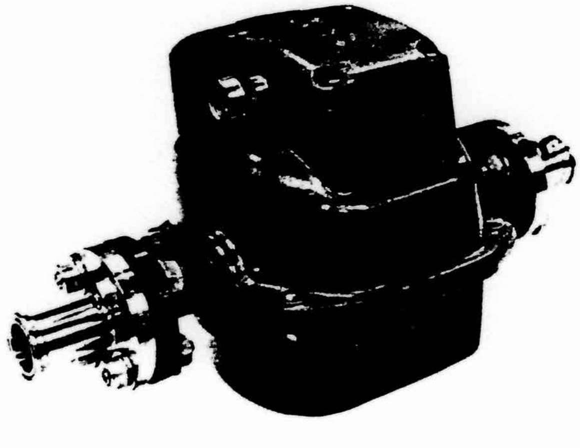


Figure 3. Sanitary Flowtube

Table 1. 2800 Series Flowtubes with ac Coil Excitation

Nominal Flowtube Size		Power Supply Frequency (Hz)	Flow Units	Nominal Upper Range Value Flow Rates[a][b]							
				ptfe or pfa Lined		Polyurethane Lined		Neoprene Lined		Unlined Glass Fiber	
mm	in			Mini-mum	Maxi-mum	Mini-mum	Maxi-mum	Mini-mum	Maxi-mum	Mini-mum	Maxi-mum
2.5	1/10	50 or 60	L/s U.S. gpm	0.0050 0.080	0.038 0.60						
6	1/4	50 or 60	L/s U.S. gpm	0.032 0.50	0.25 4.0						
15	1/2	50 or 60	L/s U.S. gpm	0.14 2.2	0.75 12						
25	1	50 or 60	L/s U.S. gpm	0.50 8.0	3.0 50						
40	1 1/2	50 or 60	L/s U.S. gpm	1.25 20	7.6 120						
50	2	50 or 60	L/s U.S. gpm	2.0 32	13 200	1.4 22	7.6 120			1.8 29	10 160
80	3	50 or 60	L/s U.S. gpm	4.5 70	30 500	3.8 60	24 385			4.5 70	25 400
100	4	50 or 60	L/s U.S. gpm	8.2 130	52 820	6.4 100	41 650			8.2 130	48 750
150	6	50 or 60	L/s U.S. gpm	19 300	115 1825	16 260	110 1800			19 300	110 1770
200	8	50 or 60	L/s U.S. gpm	34 520	200 3150	30 480	210 3300			32 520	200 3120
250	10	50 or 60	L/s U.S. gpm	50 800	320 5000	48 750	340 5400			50 800	310 4900
300	12	50 or 60	L/s U.S. gpm	75 1200	450 7150	70 1100	500 7900			70 1100	445 7050
350	14	50	L/s U.S. gpm			95 1500	680 10800	95 1500	550 8800	95 1500	535 8500
		60	L/s U.S. gpm			115 1800	680 10800	115 1800	550 8800	115 1800	535 8500
400	16	50	L/s U.S. gpm			125 2000	900 14200	125 2000	720 11500	125 2000	695 11000
		60	L/s U.S. gpm			150 2400	900 14200	150 2400	720 11500	150 2400	695 11000
450	18	50	L/s U.S. gpm			160 2500	1150 18200	160 2500	930 14700	160 2500	880 14000
		60	L/s U.S. gpm			190 3000	1150 18200	190 3000	930 14700	190 3000	880 14000
500	20	50	L/s U.S. gpm			200 3150	1430 22600	200 3150	1160 18400	200 3150	1100 17500
		60	L/s U.S. gpm			240 3800	1430 22600	240 3800	1160 18400	240 3800	1100 17500
600	24	50	L/s U.S. gpm			320 5000	2050 32500	320 5000	1690 26800	320 5000	1580 25000
		60	L/s U.S. gpm			380 6000	2050 32500	380 6000	1690 26800	380 6000	1580 25000
750	30	50	L/s U.S. gpm			475 7500	3250 51500	475 7500	2670 42200	475 7500	2570 40800
		60	L/s U.S. gpm			570 9000	3250 51500	570 9000	2670 42200	570 9000	2570 40800
900	36	50	L/s U.S. gpm			660 10500	4730 75000	660 10500	3860 61200	660 10500	3720 59000
		60	L/s U.S. gpm			790 12500	4730 75000	790 12500	3860 61200	790 12500	3720 59000

(a)For all but the 2.5 mm (1/10 in) flowtube, the minimum upper range value flow rates can be reduced to 50% of the value listed. This is accomplished by using an alternate coil connection and/or voltage arrangement. Refer to PSS 1-6B5 A and PSS 1-6B5 C.
(b)Recommended limits. Flow velocities to 9 m/s (30 ft/s) are permissible but may accelerate lining wear.

Table 2. 2800 Series Flowtubes with Pulsed dc Coil Excitation

Nominal Flowtube Size		Flow Units	Nominal Upper Range Value Flow Rates[a]							
			ptfe or pfa Lined		Polyurethane Lined		Neoprene Lined		Unlined Glass Fiber	
mm	in		Mini-mum	Maxi-mum	Mini-mum	Maxi-mum	Mini-mum	Maxi-mum	Mini-mum	Maxi-mum
2.5	1/10	L/s U.S. gpm	0.0025 0.040	0.038 0.60						
6	1/4	L/s U.S. gpm	0.0012 0.019	0.25 4.0						
15	1/2	L/s U.S. gpm	0.038 0.60	0.75 12						
25	1	L/s U.S. gpm	0.15 2.3	3.0 50						
40	1 1/2	L/s U.S. gpm	0.38 6.0	7.6 120					0.50 8.0	10 160
50	2	L/s U.S. gpm	0.66 10.5	13 200	0.32 5.0	7.6 120			1.3 20	25 400
80	3	L/s U.S. gpm	1.5 23	30 500	0.98 22	24 385			2.5 40	48 750
100	4	L/s U.S. gpm	2.5 40	52 820	1.6 26	41 650			5.7 90	110 1770
150	6	L/s U.S. gpm	5.7 90	115 1825	4.4 70	110 1800			10 160	200 3120
200	8	L/s U.S. gpm	10 160	160 3150	8.2 130	210 3300			16 250	310 4900
250	10	L/s U.S. gpm	16 250	320 5000	14 220	340 5400			22 350	445 7050
300	12	L/s U.S. gpm	22 350	450 7150	20 320	500 7900			26 420	535 8500
350	14	L/s U.S. gpm			27 430	680 10800	28 440	550 8800	35 550	695 11000
400	16	L/s U.S. gpm			36 570	900 14200	36 580	720 11500	44 700	880 14000
450	18	L/s U.S. gpm			46 730	1150 18200	47 740	930 14700	109 1730	1100 17500
500	20	L/s U.S. gpm			114 1815	1430 22600	116 1840	1160 18400	237 3750	1580 25000
600	24	L/s U.S. gpm			246 3900	2050 32500	252 4000	1690 26800	388 6150	2570 40800
750	30	L/s U.S. gpm			391 6200	3250 51500	397 6300	2670 42200	568 9000	3720 59000
900	36	L/s U.S. gpm			568 9000	4730 75000	580 9200	3860 61200		

(a)Recommended limits. Flow velocities to 9 m/s (30 ft/s) are permissible but may accelerate lining wear.

Electrodes The standard electrode in 2800 Series Magnetic Flowtubes is AISI Type 316L stainless steel. This metal satisfies the non-magnetic requirement, and has more than adequate corrosion resistance for many applications. Platinum–10% iridium and other more highly corrosion resistant electrode metals, including Hastelloy C, titanium, and tantalum, are optionally available on certain 300 mm (12 in) and smaller size flowtubes.

On 15 mm (1/2 in) and larger size flowtubes, the electrodes are inserted from inside the tube*. The threaded end of the electrode extends outside the tube. Flush with the tube inside wall, the head of the electrode bears against the lining surface. On lined-metal tubes, electrodes are electrically insulated from the tube. An electrode assembly for a ptfe-lined flowtube is shown in Figure 4.

Special care is given to electrode sealing. Electrodes are bonded into unlined glass fiber-reinforced resin flowtubes to assure electrode seal integrity. In polyurethane-lined flowtubes, the electrodes are molded in the liner. Equally good sealing is obtained by torquing electrodes against Neoprene linings. The characteristic cold flow property of ptfe and pfa, however, has to be overcome by more rigorous electrode sealing procedures. Electrode sealing surfaces are grooved to provide additional sealing surface and to firmly grip the lining. When installed, the electrodes are tightened firmly against the lining. The correct sealing pressure against the ptfe is maintained by a series of Belleville spring washers. With a pfa liner, the correct sealing pressure is maintained by means of a coil spring.

Pipeline Connections Flange end connections are the usual means of mounting a flowtube into a process pipeline. On 300 mm (12 in) and smaller sizes of lined-metal flowtubes, slip-on (welded) AISI Class 150 RF (raised face) or PN 10 flanges are standard. The flange material is either stainless steel [for 2.5 and 6 mm (1/10 and 1/4 in) sizes] or carbon steel [for 15 through 300 mm (1/2 through 12 in) sizes]. The larger lined-metal flowtubes are supplied with AWWA Class 125 flat face or PN 10 raised face carbon steel flanges.

Sanitary flowtubes have stainless steel extensions with quick-disconnect type connections. The extensions are bolted to the flanged ends of a ptfe-lined flowtube. Flowtube with ANSI Class 150 flange has a Tri-Clover extension which mates to a Tri-Clamp on the process piping. Flowtube with PN 10 flange has a sanitary coupling extension (DIN 11851, BS 1864, BS 4825, or ISO 2853, as specified) with an external thread. Mating clamps, connections, and gaskets are supplied by the user. Sanitary flowtubes are used with the next larger line size as listed in the table below.

Sanitary Flowtube and Corresponding Line Sizes

Nominal Flowtube Size		Nominal Line Size	
mm	in	mm	in
15	1/2	25	1
25	1	40	1 1/2
40	1 1/2	50	2
50	2	80	3
80	3	100	4

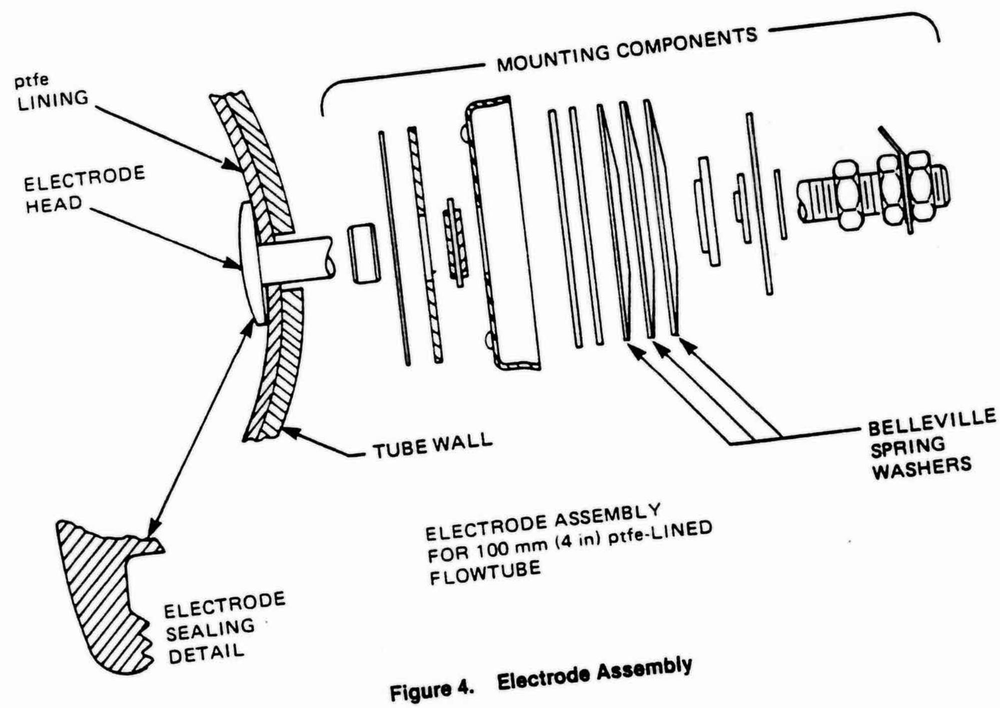


Figure 4. Electrode Assembly

* ...smaller sizes, electrodes are inserted from outside the tube.

On unlined resin flowtubes, flat-face flanges (of the same material as the tube) are standard for 600 mm (24 in) and smaller sizes. The largest unlined resin flowtubes, 750 and 900 mm (30 and 36 in), have plain ends suitable for use with Dresser couplings.

Various optional flanges are available. Up to 200 mm (8 in) sizes of ptfe- and polyurethane-lined 2800 Series Flowtubes can be supplied with heavier flanges, ANSI Class 300 RF, PN 40, etc. Also available are AISI Type 316 stainless steel flanges with selected flowtubes.

Process Earth (Ground) The electrical continuity of the process and pipeline must be maintained. This is accomplished through the metal tube and the flange bolts (or quick-disconnect clamps). With unlined resin tubes, it is achieved by means of a metal strip on the outside of the flowtube, in contact with the flange bolts. When the flowtube is connected to a lined or non-metal pipe, earthing rings (grounding rings) are used to provide the required continuity. Use of grounding rings is discussed later in "Piping Considerations."

Coil Assembly and Lead Wires

Coils The design for the 2800 Series Flowtube coils has been enhanced by many years of experience in producing dependable industrial-grade magnetic flowtubes. High wire density (see Figure 5) allows a strong magnetic field to be generated in a minimum space with low power consumption. On ac systems, the coils can be connected in series or parallel. They are normally connected in series for minimum power consumption. When they are connected in parallel, the magnetic field is doubled, and the flowtube output signal is thus doubled. As noted in a footnote of Table 1, this permits lower minimum upper range values. Coil wires have high temperature insulation so as not to be a factor in determining high process temperature limits. Coils for 300 mm (12 in) diameter and smaller sizes, have a rectangular cross-sectional area to provide a precise, extremely sturdy assembly. All sizes of 2800 Series Flowtubes are virtually immune to shock or vibration.

Core The purpose of the core, which is mounted around the coils, is to complete the magnetic circuit and to magnetically shield the measuring zone. To minimize power waste and heat buildup from eddy currents, the core is laminated transformer steel. The core/coil/tube assembly is an extremely sturdy unit, built for dependable and accurate performance, despite heavy mechanical shock or pipeline vibration.

Lead Wires Protected by driven screens (shields), lead wires conduct the low-level measurement voltage from the electrodes out through the magnetic field to terminals for connection to a transmitter. A separate driven screen encloses each measurement lead wire. These screens are driven by the transmitter to the same potential and phase as are on the leads, providing the ultimate protection against signal loss due to capacitance. Proper positioning of the leads within the housing, in the magnetic field, minimizes spurious voltage pickup and distortion of the measurement. Access is provided on 2800 Series Flowtubes to adjust lead wires to the optimum contour. This is used when field repairs (especially replacement of a flowtube) are required.

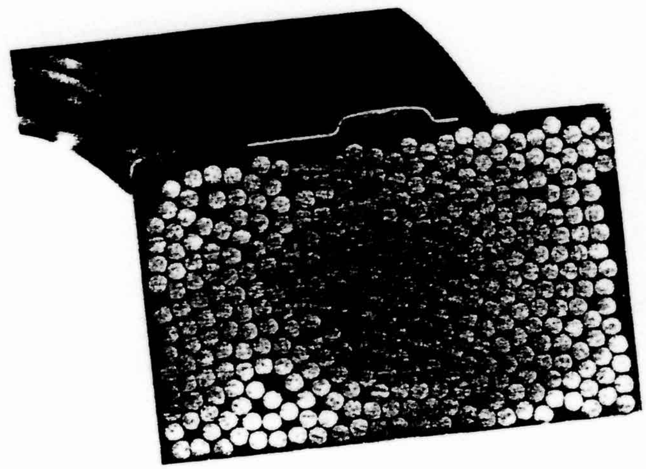


Figure 5. Field Coil Cross-section

Housings

The coils, cores, wires, etc., of 2800 Series Flowtubes are enclosed by a sealed housing for protection from moisture or other harmful external elements. Two integral but separate connection boxes, one for power and the other for measurement wiring (see Figure 6), are located at the top of the housing. When used in ac systems, jumpers in the power connection box are used to connect the coils either in series or parallel. Because magnetic flowtubes must often operate in harsh environments, housing materials must withstand a variety of corrosive atmospheres. For flowtubes 300 mm (12 in) diameter and smaller, low-copper content cast aluminum alloy is the housing material; these housings meet IEC IP65 requirements and provide the environmental protection of NEMA Type 4. Steel housings, which meet IEC IP65 and CSA 4 requirements and provide the environmental protection of NEMA Type 4, are used for larger flowtubes.

The high heat-dissipation rates of these metal enclosures contribute to lower temperature operation. All flowtube housings are made in two pieces, gasketed with silicone rubber sealants and bolted together, and are protected by a high-build epoxy paint*. Two versions of flowtube-mounted secondary magnetic flow instruments, the 896T and E96T Series Transmitters (see Figure 7), are available for use with 300 mm (12 in) diameter or smaller 2800 Series Flowtubes. The 896T requires pulsed dc flowtube calibration; the E96T requires ac flowtube calibration.

...be used depending on plant of manu-

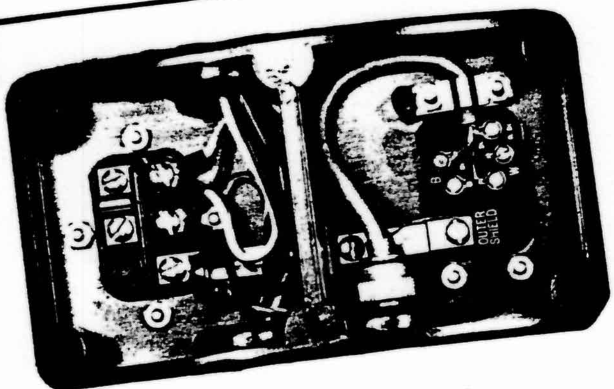


Figure 6. Connection Boxes

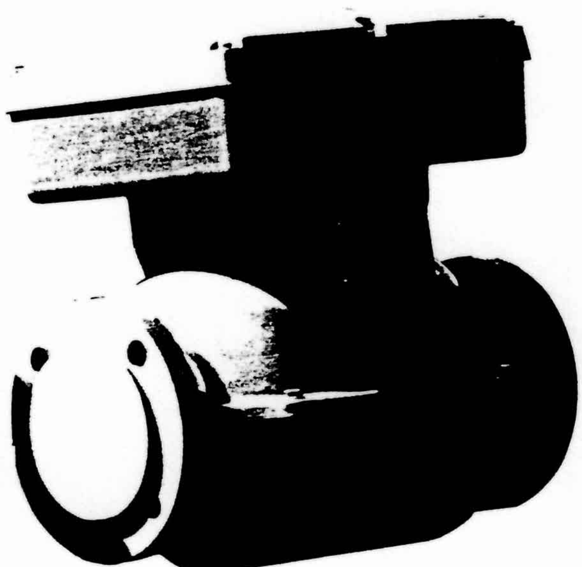


Figure 7. Transmitter Integral with Flowtube

INDUSTRIAL APPLICATIONS

Wide Areas of Use

Magnetic flowmeters are considered to be the only solution for certain difficult-to-handle (hot, corrosive, abrasive, solids-bearing, etc.) liquid or slurry metering applications. There are no differential pressure taps to become clogged or require purging. Long meter runs are normally not necessary. Magnetic flowtubes have no greater pressure drop or obstruction to flow than equivalent lengths of straight pipe. Relatively easy to install, they can be mounted at any pipeline angle. The only consideration is that the tube must be full of liquid.

Many industrial process plants necessarily have large numbers of magnetic flowtubes. In such a plant, standardization on magnetic flowtubes is an often-used means to avoid spare parts inventories for different kinds of flowtubes (and to simplify maintenance routines).

Electrical conductivity of the process liquid is the fundamental limiting factor for the application of magnetic flowmetering. Most industrial process liquids have great enough conductivity. For example, city water at 60 to 100 μS/cm or mmho/cm, or various strong acid or base solutions at as much as 10 000 μS/cm or μmho/cm. Usually, 2 μS/cm or μmho/cm, a typical value for distilled water, is regarded as the minimum. Liquids with lower conductivity values can be considered, but they must be examined on an individual basis. The lower limit in any particular application depends upon the length of cable between flowtube and transmitter.

Selecting E96 or 896 Systems

Foxboro E96/2800 magnetic flow metering systems provide accurate flow measurement for virtually all types of conductive liquids in a variety of applications.

The Foxboro 896/2800 magnetic flow metering systems provide very high accuracy flow measurement on many types of conductive liquids and range of applications. However, these systems should not be used for certain applications. For example:

- non-homogeneous liquids
- slurries with high solid content
- processes with entrained air or gases
- applications involving fast changing or pulsating flows

Process Variations

Conductivity changes in process liquids can occur due to changes in composition and other reasons. However, if the conductivity value does not drop below acceptable levels, this will not affect accurate magnetic flow measurement.

A magnetic flowmeter measures the average liquid velocity through the flowtube. Variations in liquid composition (unless they change velocity or reduce conductivity below the minimum) have no effect on the measurement. For example, viscosity or density changes do not affect magnetic flow measurements.

Also, changes in process liquid temperature or pressure have no effect. These parameters, and combinations of them, must only be maintained within the wide limits published in 2800 Series Flowtube specifications.

In ac systems, variation in line voltage or frequency will cause a change in the measurement voltage generated. Automatic compensation is made for these variations by the transmitter. For accurate, total compensation to be effective, power must be wired directly to the flowtube and supplied, in parallel, to the transmitter from terminals in the flowtube connection box. In this way, the exact voltage, phase, and frequency that excites the coils, is fed to transmitter compensation circuits. This design does not allow for wiring shortcuts. Following this procedure assures that complete, accurate compensation is made for any voltage surge or drop and any line frequency variation.

In dc systems, power is wired directly to the transmitter. Flowtube coil excitation power (pulsed dc) is supplied by the 896 Transmitter. Any signal variations caused by line voltage or frequency variations are small and are compensated by the transmitter.

Minimum and Maximum Flow Rates

With an 896 Series Transmitter, the minimum process-liquid upper range value (full scale) velocity is 0.3 m/s (1 ft/s). For a particular flowtube, upper range value (full scale) flow rate can be calculated by using the applicable area-times-velocity formula. The area can be determined by using the inner diameter (ID) given in tables in the flowtube Product Specification Sheet (PSS).

With an E96 Series Transmitter, the minimum upper range value (full scale) flow rate for a particular flowtube is dictated only by what flow will generate 1 mV; i.e., a velocity of 0.50 m/s (1.65 ft/s). The reason for this is that 0 to 1 mV is the lowest span acceptable by the transmitter. For example, a 25 mm (1 in) ptfe-lined flowtube, with series-connected coils powered by 120 V ac, produces 2.00 mV per L/s (0.125 mV per U.S. gpm). These values are the published nominal calibration factors, and dividing them into 1 mV, gives the minimum upper range value flow rate: $1 \times 2.00 = 0.5$ L/s ($1 \times 0.125 = 8$ U.S. gpm). However, this flow rate corresponds to a very low process liquid velocity, approximately 1.1 m/s (3.5 ft/s). When the velocity of a "dirty" liquid is this low, suspended materials tend to settle. Therefore, when the application is for a liquid known to deposit coatings inside the pipe, the flowtube should be sized for as high a velocity as possible to help keep potential coating materials moving with the stream and to scrub away previously-formed deposits. See "Buildup in Flowtubes" section.

Recommended maximum upper range value (full scale) flow rates are based upon velocities of 6.1 m/s (20 ft/s) in ptfe and Neoprene lined-metal, as well as in unlined resin tubes. In pfa and polyurethane lined-metal tubes, maximum flow rates are based on velocities of 7.6 m/s (25 ft/s). These recommendations (although based upon wear-and-tear resistance of the tube material) are somewhat arbitary, and some users choose to exceed them. There are potential problems in doing this. Primarily, accelerated wear inside the tube will shorten the life of the flowtube. Also, there is a greater chance of damaging a flowtube (especially an unlined glass fiber-reinforced resin tube) if a severe hydraulic shock (usually caused by excessively fast valve action) occurs during a period of excessively high liquid velocity. Such pressure surges ("water hammer") must be avoided, for example, above 4.5 m/s (15 ft/s) in 50 mm (2 in) size resin flowtubes, and above 1.5 m/s (5 ft/s) in 300 mm (12 in) size resin flowtubes. Apart from these considerations, magnetic flowmeters can operate satisfactorily, even when there are excursions in flow rate above recommended maximums. However, the design of Foxboro magnetic flow transmitters limits the upper range value (full scale) flow rate to a maximum of 9 m/s (30 ft/s).

Buildup in Flowtubes

Low-level voltage, generated by liquid flowing through the magnetic field, is conducted into the leads (and transmitter circuits) by the electrodes. If coatings form on the electrodes and create a very high resistance, the measurement signal can become erratic. A coating on the liner can also be troublesome in some cases.

To prevent error-causing electrode coatings, attention should first be directed to proper sizing of the flowtube. With "clean" liquids—those which do not precipitate nonconductive coatings on the electrodes—flowtube sizing is a simple matter.

It is usually assumed, that if a flowtube has the same diameter as the pipeline, it is properly sized. This is not always true with "dirty" liquids, even if the upper range value flow rate is within the published minimum and maximum for the flowtube. For instance, an expected flow rate of 5 L/s (80 U.S. gpm), in an 80 mm (3 in) ptfe-lined flowtube, amounts to approximately 1.2 m/s (3.8 ft/s) velocity. If the liquid tends to make deposits, a better choice would be a 50 mm (2 in) flowtube in which this same flow rate gives approximately 2.4 m/s (8 ft/s). If pressure drop in the pipeline is not critical, a 40 mm (1 1/2 in) flowtube could also be considered because of the much higher velocity, almost 4 m/s (14 ft/s).

In some "dirty" liquid applications, high velocity is either impractical or ineffective as a means of keeping electrodes clean. For liquids not containing abrasive particles, altering the flow profile or increasing liquid turbulence with pipe elbows or other flow conditioning devices is sometimes an adequate solution to this problem. However, if the liquid does contain abrasive particles, consideration must be given to another potential problem: impact of abrasive flow upon a lining can accelerate wear.

Standard electrodes are essentially flush with the inside surface of the flowtube. At this surface, the liquid velocity is minimal, even at high flow rates. For process liquids which leave deposits on electrode surfaces, optional conical electrodes which protrude into the flowstream, might be successfully applied. The cones extend in from the tube wall to where the liquid velocity is more likely to inhibit coating.

For applications where these techniques do not solve coating problems, Foxboro offers a unique choice of twc electrode cleaning options. One of the choices, the low voltage electrode cleaning technique, provides a mean of applying a low voltage between electrodes and liquid t remove buildup. The other electrode cleaning devic available on 2800 Series Flowtubes is an ultrasonic osc lation type. Ultra-high speed mechanical motion of t electrodes prevents or removes many kinds of coatin Both of these choices are listed in "Optional Featur on Page 11.

Piping Considerations

To avoid excessive lining wear from abrasives, and possible loss of accuracy, the upstream side of the flowtube should be mounted to a straight section of pipe which is at least five pipe diameters in length. Continuity between the flowing liquid and the flowtube is required to provide a reference for the measurement signal. With metal pipe connected to a flowtube flange, the continuity is provided by the pipe and the flange bolts. Installations in which nonmetal or lined-metal pipe is connected to the flowtube, earthing rings (grounding rings) must be used. These rings are installed between the pipe and the flowtube flanges. A wire between the grounding ring and one of the flange bolts provides the required continuity between the liquid and the metering tube. To provide positive contact with the liquid, the inner diameter of the grounding ring should be slightly less than that of the metering tube. A grounding ring is also sometimes installed in the upstream side of a lined metal flowtube to protect the inner edge of the liner from wear. This is especially true when measuring the flow of an abrasive liquid.

PRODUCT SAFETY

These flowtubes are designed to satisfy personnel safety requirements and to minimize potential shock and casualty hazards. They are also designed to be a minimum fire hazard by use of adequate insulation and separation of circuits. Standard requirements of Factory Mutual or Canadian Standards Association (FM or CSA) are generally fulfilled, as well as the concensus standards adopted by the Occupational Safety and Health Administration (OSHA). Meeting these standards generally satisfies similar requirements for use in other parts of the world.

ac Calibrated Flowtubes

For ac systems, the 2800 Series Flowtubes in sizes from 15 through 900 mm (1/2 through 24 in) are certified by FM and CSA as suitable for use in ordinary locations and in Class I, Groups B, C, and D, Division 2 hazardous locations. Sizes 2.5 and 6 mm (1/10 and 1/4 in) are certified by Foxboro for use in these same locations.

Pulsed dc Calibrated Flowtubes

For pulsed dc systems, 2800 Series Flowtubes in sizes 2.5 through 900 mm (1/4 through 24 in) are Foxboro self-certified for use in ordinary locations and in Class I, Groups B, C, and D, Division 2 hazardous locations as defined by FM or CSA.

OPTIONAL FEATURES

Hazardous Locations Installations

A Type Y purging option is available on 300 mm (12 in) and smaller sizes of pfa-, ptfe-, and polyurethane-lined flowtubes which are otherwise certified by FM or CSA for Division 2 hazardous locations. With Type Y purging, the atmosphere in the housing is maintained at Division 2 conditions in spite of a more hazardous Division 1 surrounding atmosphere. This permits operation in a Division 1 area if the outside of the housing and the purge air exhaust do not provide a possible source of ignition. The system is designed per the National Fire Protection Association (NFPA) "Purge Enclosures for Electrical Equipment" (document number 496). Prior to energizing the flowtube, there must be an initial purge equal to four times the internal housing volume. During operation, a purge flow rate indicator is required to verify purge protection.

For European use, an optional Physikalisch-Technische Bundesanstalt (PTB) approved version of ac-calibrated flowtubes is available. They can be supplied in sizes 15 mm (1/2 in) through 150 mm (6 in) with ptfe or polyurethane lining. The signal circuit is modified to meet the requirements of intrinsic safety by PTB definition for use in Group IIC, Zone 1 hazardous locations. They are PTB certified explosion-protected according to VDE 0171 protection methods "Intrinsic Safety" $(Ex)_i$G5, and "Increased Safety" $(Ex)_e$G(3, 4, or 5). (Manufactured in The Netherlands). The flowtube must be used with the PTB certified version of the Foxboro E96 Series Transmitter. Mains connections meet PTB increased safety requirements. Among the limitations of these systems, ultrasonic cleaning and Type Y purging cannot be used. Also, field coils must be factory-wired for either series or parallel operation and cannot be changed on site.

Submersible Operation

The 2800 Series Flowtube can be encased in a watertight enclosure for continuous operation of the flowmeter when the flowtube is submerged in as much as 3 m (10 ft) of water. The housing is prepared with special RTV sealing and then pressure tested. The flowtube assembly is coated with N-55 Neoprene which provides a second moisture seal plus added protection against corrosion. An ample supply of RTV 602 potting compound is included to seal signal and power connections during installation.

Accidental Submergence

This option provides a watertight enclosure which protects the flowmeter from accidental submergence in as much as 9 m (30 ft) of water for a period of up to 24 hours. Typical use is in a municipal waste pit which could overflow during heavy rain. The housing is coated with an epoxy paint, sealed with RTV, and then pressure tested. A supply of RTV 602 potting compound is included to seal signal and power connections during installation.

Corrosion-Resistant Coating

For operation in extremely corrosive environments, a superior corrosion-resistance option is available for 300 mm (12 in) or smaller flowtubes. Applied to the housing is a chip-resistant, baked-on dispersion coating of vinylidene fluoride. It is porosity-free and nonpermeable, and it resists corrosion from most strong industrial chemicals, including hot caustic liquids.

Lining Flare Protection

In addition to spool pieces and other optional parts for flowtube flanges, a ptfe lining protection device is available. It consists of a pair of stainless steel rings which fit around the outer diameter of the flange raised faces and extend beyond the raised faces, approximately 15 mm (0.5 in) on each end. The rings are spot-welded in place. They help prevent lining damage if flange bolts are over-torqued. Also, if a prying tool is used to remove a flowtube from a pipeline, the rings help to prevent cuts in the lining flare. A pair of thick, solid ptfe gaskets are supplied to cover the lining flares (inside the rings) to effect a good flange joint seal without lining damage.

Conical Electrodes

Conical-shaped electrodes are optionally available on ptfe-lined 2800 Series Flowtubes from 25 mm (1 in) up to 300 mm (12 in) in size. There is a choice of AISI Type 316 stainless steel or Hastelloy C metal for these electrodes.

Low-Voltage Electrode Cleaning Assembly

This low-energy electrode cleaner is used to remove sludge and film deposits from the electrodes. The output of the cleaner is a nominal 24 V ac (50 or 60 Hz) through a current-limiting 5000 Ω resistor.

Ultrasonic Cleaning

To protect against the formation of insulative coatings on the flowtube electrodes (and eventual loss of measurement accuracy), an ultrasonic cleaner can be used. Foxboro offers a choice of cleaner options. With one option, the cable from the oscillator power supply is connected directly to terminals inside the flowtube housing. Another option is to have a junction box wired to the flowtube terminals. This option is used for the portable electrode cleaner. The 1.5 m (5 ft) screened (shielded) cable from the oscillator power supply is terminated with a connector which plugs into the junction box.

For most applications, the ultrasonic cleaner should be operated continuously to provide maximum protection against the formation of insulative coatings. For such cases, the direct-wired oscillator power supply is the most economical installation. When intermittent electrode cleaning is permissible, the portable ultrasonic cleaner can be used. With this option, the oscillator power supply can be easily disconnected from one flowtube and connected to another, permitting periodic cleaning of several electrodes using a single power supply.

The electrode cleaning action results from vibrations of 65 ±10 Hz impacted to the electrode surfaces. The cleaner itself consists of two main components: a pair of electrode drivers (inside the flowtube housing) and the external oscillator power supply. The drivers are mechanical assemblies of stainless steel parts and a washer-shaped piezo ceramic element. Electrostatic screening is utilized in ultrasonic cleaning assemblies to [illegible] any disturbance in the flow measurement. Ultrasonic cleaning is available with all 50 mm (2 in) and larger sizes of 2800 Series Flowtubes with standard housings and stainless steel electrodes. It is also available in 50 through 300 mm (2 through 12 in) flowtubes with Hastelloy C or titanium electrodes. It is not available with PTB approved versions of flowtubes.

High Calibration Accuracy for ac Systems

For 2800/E96 installations which require higher accuracy, optional system accuracy calibration can be performed in the Foxboro Flow Laboratory. This feature provides improved system accuracy because the particular flowtube and transmitter to be used together are calibrated together. These specially calibrated systems include a 2800 Series Flowtube (any size or version) with an E96 Series Transmitter and optional counter (if present). A Foxboro electronic recorder can also be included in a calibrated system.

Replaceable Metering Tube Assemblies

To enhance on-site repair capability of 2800 Series Flowtubes, precision replacement metering tubes are available. The lining and flanges are included, completely assembled with electrodes and wiring terminal blocks. A typical replacement tube assembly is illustrated in Figure 8. Other parts, such as field coils and housings, are also available as replacement items. They can be stocked and installed on site to minimize downtime. The simple replacement operation is described in Instruction MI 021-181.

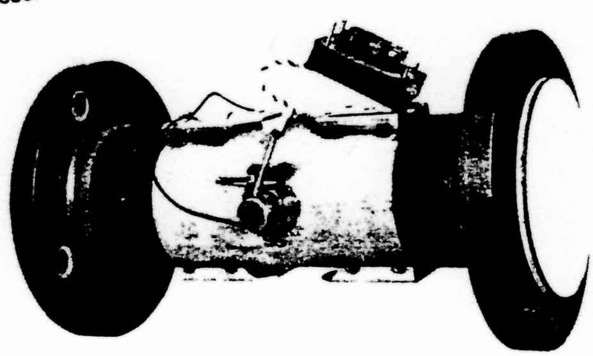


Figure 8. Replaceable Metering Tube Assembly

SUMMARY

Developed from the “know-how” of over 30 years of e
perience in manufacturing thousands of quality magnet
flowmeters for industry and specialized applications, Fc
boro 2800 Series Magnetic Flowtubes offer excelle
value. This discussion covers the proven design featu
of these flowtubes, and details their sturdy compone
and assembly techniques. Safety aspects and added
satility with optional features are also discussed. Mar
the reasons are given for the high performance anc
pendability which make the 2800 Series Magnetic F
tube your first choice for flow metering application